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# ANNUAL PROGRESS REPORT

# CIVIL DEFENSE RESEARCH PROJECT

# MARCH 1967–MARCH 1968

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**OAK RIDGE NATIONAL LABORATORY**
operated by
UNION CARBIDE CORPORATION
for the
U.S. ATOMIC ENERGY COMMISSION

ORNL-4284
Part I

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CIVIL DEFENSE RESEARCH PROJECT
Director's Division

# ANNUAL PROGRESS REPORT
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# MARCH 1967-MARCH 1968

NOVEMBER 1968

OAK RIDGE NATIONAL LABORATORY
Oak Ridge, Tennessee
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UNION CARBIDE CORPORATION
for the
U. S. ATOMIC ENERGY COMMISSION

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*Annual Progress Report, Civil Defense Research Project, March 1967 - March 1968, ORNL-4284, Part II (Formerly Restricted Data, Classified).

V. WEAPONS EFFECTS

# I. FOREWORD

The Oak Ridge National Laboratory Civil Defense Research Project, jointly sponsored by the Department of Defense and the Atomic Energy Commission during the past three and one-half years, consists of an interdisciplinary study of the problems of advanced civil defense systems which might be installed during the 1970's. This is the fourth in a series of progress reports--the first* covered topics studied during the first six months of the project and the second** and third,*** topics during the next two full years.

This fourth report and its classified supplement contain the results of research in fifteen areas related to civil defense. The summaries of the individual chapters and the chapters themselves can perhaps be conveniently introduced and related to each other by following the format used in the last two years' reports, listing a series of fifteen problems and comments or partial solutions related to the effectiveness of advanced civil defense and following the report's chapter sequence.

1. Problem: During this report period the Department of Defense announced the beginning of its deployment of a light missile defense system, possibly the single most important component of a total U.S. strategic defense system. Does missile defense eliminate the need for civil defense? If not, how does a light defense affect the feasibility of advanced civil defense systems?

Comment: Although the interaction of missile defense and civil defense is complex, it is probable that missile defense enhances the capability of any civil defense system. We will assume that the

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*Civil Defense Study Group Progress Report, September 1964-March 1965, ORNL-TM-1120 (Classified).

**Annual Progress Report, Civil Defense Research Project, March 1965-March 1966, ORNL-TM-1531, Part I, ORNL-TM-1531, Part II (Classified).

***Annual Progress Report, Civil Defense Research Project, March 1966-March 1967, ORNL-4184, Part I, ORNL-4184, Part II (Classified), ORNL-4184, Part III (Classified).

attacker's response to our deployment of area defense is to overwhelm it by refitting his boosters with many multiple warheads. Multiple warheads are more expensive and therefore increase the cost-effectiveness of advanced civil defense systems. Quantitative studies of this and other strategic defense interactions are contained in Chapter 1.

2. The problem of the electromagnetic pulse (EMP) accompanying a nuclear detonation and its effect on civil systems is discussed in Chapter 2, Part II (the classified supplement to this report) along with possible counter-measures.

3. **Problem:** Interconnected urban tunnels have been described as potentially effective blast shelters which offer the possibility of a gradual reduction in the vulnerability of the occupants by movement through the tunnels. However, all blast shelters may require rapid response (less than a half hour) to a warning system in order to reduce the initially high vulnerability of urban populations to nuclear attack. Can present warning systems be improved sufficiently to meet this requirement?

Comment: The value of the TEST (Tactical Evacuation to Shelters through Tunnels) system is being studied quantitatively. As part of the first stage of the study, the time required to reach a given tunnel entrance is compared for present and future warning systems in Chapter 3.

4. Problem: A systematic study of civil defense problems involves consideration of many technical, economic and social factors which influence the design and performance of alternative systems. Collection and retrieval of useful civil defense information across so many discipline boundaries is a formidable task. Can modern information systems be used in such a diffuse subject area?

Comment: A small interdisciplinary program such as the ORNL Civil Defense Research Project provides a scale model laboratory for testing information retrieval methods. In Chapter 4 we report the status of an

empirical approach to the establishment of a civil defense research information center.

5. Problem: Interconnected urban tunnels seem, at least superficially, to offer many possible peace-time uses. In fact, will there be many opportunities for the installation of new tunnel systems in the crowded portions of American cities in which civil defense features can be incorporated inexpensively?

Comment: An entirely new tunnel system, such as a network of city-owned utility tunnels may provide the greatest opportunity for dual-use urban tunnel construction. An example of such a system is described in Chapter 5. However, conventional transportation systems may be increasingly placed underground. A truck tunnel has been proposed for the central business district of Dallas, Texas, and the feasibility of converting it to a dual-use shelter is examined in Chapter 6. Finally, the status of the Washington subway, in which civil defense features like those in the Moscow and Rottendam subways might be included, is reported in Chapter 9.

6. Problem: Will not the cost of equipment in a blast shelter be much larger than similar equipment in a fallout shelter since special shock isolation and perhaps equipment ruggedization may be required for blast resistance?

Comment: As the blast resistance of a shelter is increased, an overpressure regime will eventually be reached in which equipment costs are raised sharply due to shock problems. From the literature it is unclear whether standard equipment or conventional mounting will be satisfactory in the region 50-150 psi. A preliminary test of an electric generator in this regime is described in Chapter 7.

7. Problem: Might biological agents be used during a thermonuclear attack to compound passive defense problems?

Comment: One limitation on such a use of biological agents is fratricide -- that is, the sterilization of a biological aerosol by thermal radiation from a nuclear weapon. An experimental study of such a possibility, using a laser as an intense radiation source, is described in Chapter 8.

8. Problem: Assuming that shock waves which may penetrate a tunnel are attenuated by the contents of the tunnel, are engineering methods available for predicting the rate of attenuation? Entrances to the tunnel might often be placed at the base of a vertical wall. Should large overpressures be expected at the wall and ground intersection due to multiple shock reflections and are they predictable?

Comment: An extensive experimental study of the attenuation of shock waves in a four-inch shock tube has resulted in the development of engineering design equations, based on the Fanning friction factor, which are satisfactory for the prediction of shock attenuation in large diameter tunnels. The results of this work are described in Chapter 10. A theoretical method for predicting the amplification of the peak pressure at the base of a wall was compared and was found to be in good agreement with experimental results obtained with the shock tube, as described in Chapter 11.

9. Problem: The country is becoming increasingly dependent upon nuclear power for electric energy. The reactor installations are large and contain long-lived fission products. Might such reactors be attractive targets for enemy missiles, both because of their importance to the power industry and as a method of increasing the intensity of the subsequent radioactive fallout?

Comment: A preliminary analysis presented in Chapter 12 suggests that nuclear reactors are probably not attractive targets, due to their inherent hardness and to the difficulty with which the fission products in the core can be mixed with nuclear weapon fallout.

10. Problem: Are there quantitative methods available which would allow political and psychological data on the probable responses of foreign governments to new American defense systems to be considered along with technical and economical factors as a basis for policy choices?

Comment: The content analysis of foreign communications offers a possible source of such data. A pilot study of editoral studies from the Chinese Communist People's Daily is presented in Chapter 13. The results of this study suggest that an expanded analysis could be quite useful for policy purposes.

11. Problem: Public opinion polls are an important part of the American political process and with rare exceptions have been able to predict election results quite accurately. Polls have consistently shown that sixty-plus percent of the American people favor civil defense; and yet the attitude toward civil defense of the average American public during the past several years could perhaps be described as apathetic. Why this difference?

Comment: The attitudes of influential Americans affect the attitudes of the average American, essentially by definition. It is probably true that "opinion makers" are more negative on the average, in their feelings about civil defense than the general public. In an attempt to document and to explain this important difference, a research project is underway to measure the way influential Americans react to information about nuclear war. The status of this project is described in Chapter 14. Opinion analysts have noted a large increase in civil defense interest during an international crisis, and some civil defense programs have been proposed to take advantage of this phenomenon (by the construction of hasty shelters, etc.). Public opinion survey results during the 1961 Berlin confrontation were examined to determine the rate of change of civil defense attitudes and behavior as a function of education level. The results of the analysis are reported in Chapter 15. Finally, recent indications of public apathy to civil defense has been attributed to generational factors - the maturing of parts of the public who have not experienced a time of severe threat to U.S. security. A longitudinal (trend over time) examination of defense attitudes is reported in Chapter 16.

12. Problem: Civil defense operating responsibilities were assigned by President Kennedy in 1961 and 1962 to most executive departments and agencies. A future increase in the national investment

in shelter or warning systems, which are the responsibility of the Defense Department under the Office of Civil Defense, would probably be accompanied by increases in other emergency programs, such as emergency medical services. Disaster hospitals are stored in many communities, but most of the medical profession has not taken an active interest in planning for a nuclear emergency. How can disaster medical care ever be adequate for civil defense purposes?

Comment: During the past several years the medical stock-pile program of the Public Health Service, which is one of the important parts of disaster medical care, has been considerably strengthened. In Chapter 17 the program changes which led to this enhancement are examined, and the implications for improvements in other emergency programs are emphasized.

13. Problem: After a nuclear attack on the United States, food production may be severely reduced and, in many sections of the country, temporarily interrupted. Stored food, such as processed food, grain and livestock, would have to supply the nation's food needs until adequate production and imports could be reestablished. In view of the current emphasis on world food problems and declining U.S. reserves, is there enough food to meet our emergency requirements?

Comment: The total food supply in the United States appears to be adequate, but its location is poorly matched with population distribution. The importance of our grain reserves is discussed in Chapter 18. In Chapter 19 the value of even low radiation protection for livestock survival is described. The special case of the Tennessee livestock industry is examined, using the fallout patterns from the UNCLEX attack.

14. Problem: The location and quantity of our food reserve seems to be the result of normal market forces rather than specific emergency planning. What would be the cost of a food reserve program designed specifically for civil defense?

Comment: In Chapter 20 an idealized program consisting of stored conventional foods is examined to place an upper bound on cost. Such a program would require an annual investment of almost seven billion dollars. A more attractive plan, requiring additional research, would

use stored whole grain (redistributed to match population) as the primary component of a food reserve.

15. Problem: After a nuclear attack, the demand for goods might greatly exceed the supply. If severe inflation resulted, investments in the rebuilding of damaged industries might be curtailed. Government price controls are often circumvented by the black market. How might the United States establish an emergency economic control policy which would offer a better chance for promoting post-attack recovery?

Comment: One alternative to wage and price control is the use of blocked accounts which has the effect of requiring the saving of surplus money. A preliminary investigation of such an economic recovery program is contained in Chapter 21.

J. C. Bresee
Project Director

Note: Throughout this report a reference in the text to a figure (e.g., Figure 2) in any chapter (e.g., Chapter 11) designates the number on the actual drawing or photograph <u>following</u> the decimal place with the number preceding the decimal place being the chapter number (e.g., Figure 11.2).

# II. SUMMARIES

## CIVIL DEFENSE SYSTEMS ANALYSIS

### Chapter 1. Blast Shelter Systems with a Light, Area Ballistic Missile Defense

R. A. Uher

We report the progress of a study of the role of a blast shelter system in strategic defense. First, we discuss blast shelter systems which are not protected with ballistic missile defense. For the analysis, we assume that an attacker launches 10 megaton weapons targeted to destroy as many people as possible. Blast shelter systems are described which protect the maximum number of people against such attacks. Finally, we discuss blast shelter systems protected by a light, area-type ballistic missile defense.

There are two categories of blast shelter systems defended by area defense. The first kind of system (referred to as non-optimum) has a single shelter type and shelters people living in high population density areas. Systems in the second or optimum category consist of shelters whose protection level varies continuously with population density. At any defense expenditure, the optimum systems are designed to produce minimum fatalities against an attack designed to produce maximum fatalities.

The results show that non-optimum shelter systems save the most people when their protection level lies between 80 and 120 psi. Optimized attacks against non-optimum systems costing 10 billion dollars produce fatalities 10-15% higher than against corresponding optimum systems. At a 30 billion dollar defense expenditure, fatalities for non-optimum systems run 20-40% higher than optimum systems.

## Chapter 2. The Effect of Electromagnetic Pulse on Civil Systems

D. B. Nelson

(Reported in Annual Progress Report, Civil Defense Research Project, March 1967-March 1968, ORNL-4284, Part II (Classified))

## Chapter 3. Civil Defense Systems Analysis

C. M. Haaland

Three preliminary investigations have been made as a part of a general analysis of civil defense systems. One of the studies presents an overview of civil defense functions and systems by means of Venn diagrams.

Preliminary studies on the TEST (Tactical Evacuation to Shelters through Tunnels) system are described. The time required to reach a tunnel entrance is the sum of threat realization time in response to the warning system, plus reaction time and time for movement. The warning system is divided into the mechanical system and the human system. A comparison is presented of the probable warning and response characteristics for the present and future systems in the classified supplement listed above.

The problem of the flow of people from the evacuation area into the tunnels is discussed, and a graphical solution to a simplified situation is presented to obtain the linear density in the tunnels as a function of time, position, and the density of people in the evacuated area.

## Chapter 4. Preparing for a Civil Defense Research Information Center: An Empirical Approach

J. S. Levey

The purpose of this study is to prepare the way for an information center on civil defense research information and to determine the shape of the future center: its scope, purposes, services, and methods. The approach has been: (1) to test methods of information handling, such as using the KWIC (Key-Word-In-Context) computer program to provide subject handles for retrieving reports, (2) to explore sources of civil defense research information by seeking specific information in answer to staff needs, (3) to get an indication of the scope of civil defense research by analyzing the content of current research programs and the rate of literature published as a result of this research, (4) to gain insight into the information resources, information barriers, and information requirements of civil defense researchers by conducting in-depth interviews with the interdisciplinary staff of the Civil Defense Research Project, and (5) on the basis of the results of the foregoing to indicate the kind of research information center that could best serve the needs of the civil defense research community.

In view of the nature of the civil defense research enterprise, an information center would have to be broad in the scope of its coverage. The combined experiences of the ORNL Civil Defense Research Project - its report collection, information resources and research results - can furnish a nucleus of information useful to other civil defense researchers. The needs of the ORNL Civil Defense staff point to a center which would collect, analyze, evaluate, and retrieve the report literature. The center would also provide abstracts of current literature, bibliographies, state-of-the-art reports, and a place to visit with specialists. To serve the civil defense research community, a mechanized retrieval capability is called for.

# CIVIL DEFENSE PROTECTIVE SYSTEMS

## Chapter 5. Dual-Use Utility Tunnels

W. J. Boegly, Jr., W. L. Griffith, and K. F. Nelson

As a part of the engineering studies on dual-use of various urban structures for blast shelters, the feasibility of providing utility tunnels in urban areas is being assessed. The White Plains Central Renewal Project was selected as the site for these studies. A tunnel system for the area would require about 7,000 feet of tunnels at a cost of approximately $4,400,000. Cost benefit studies indicate that if the tunnel is financed under urban renewal procedures, sufficient revenue can be obtained to repay the city's cost. Conversion of the White Plains tunnel to dual-use blast shelters would require an investment of $250 to $310 per inhabitant, depending on the length of time provided for isolation of the shelter from the outside air and the shelter population to be protected. At least half the shelter investment is postponable. At the time of the installation of a utility tunnel an investment of $120-$140 per person to be sheltered would "buy an option" for later conversion of the system to a high-grade shelter.

## Chapter 6. Dallas Dual-Use Truck Tunnels with Portable Columns

C. J. Williams and R. P. Kennedy

Portable columns can be used to strengthen wide concrete spans at a cost advantage compared with an unsupported thicker span. Peacetime uses requiring wide spans, such as tunnels, parking garages and below-grade storage areas, can be retained with portable columns placed at the time of an emergency.

Using a truck tunnel designed for Dallas, Texas, the comparative cost of various levels of blast protection was evaluated with and without columns. The results showed a significantly lower cost with columns.

Portable columns could also be installed in existing buildings to strengthen below-grade areas. The calculation of the resulting increase in blast resistance is more difficult, since adequate steel in the reinforced concrete roof would generally not be available at the column bearing point. It is recommended that the accuracy of analytical prediction methods be evaluated by experiments performed prior to demolition of structures in an urban renewal test area.

## Chapter 7. Mechanical Equipment Shock Tolerance

C. J. Williams

Mechanical equipment in large blast shelters would be exposed to a shock pulse as the shelter responds to the ground motion produced by the air blast from an aboveground nuclear explosion. Motor generators, air conditioning equipment and blowers represent typical mechanical equipment in blast shelters, and it is necessary for shelter design to have some measure of the response of this equipment to the shock.

A 100 KW generator might be required for a typical 1000 man shelter. The purpose of the reported shock test was to determine if a standard motor generator of this size mounted in a standard way to the concrete floor of a shelter can withstand the ground shock from an aboveground explosion.

Results from this underground nuclear explosion shock test showed that direct mounting would not result in damage exposure to 15 psi overpressure from an aboveground nuclear explosion. But if the generator were in a shelter exposed to 100 psi to 150 psi from an aboveground nuclear explosion, either spring mounting or equipment strengthening would be needed to insure continuing operation.

## Chapter 8. Radiant Sterilization of Biological Aerosols

C. V. Chester

To provide the exposure of 2000 $\mu$-watt min/cm$^2$ of 2400 Å ultraviolet light necessary to kill refractory spores even in a optimized reflective

ventilation duct would produce a temperature rise of 10.5°C if the air were required to carry off the heat of the lamps. Such a system would be difficult to harden.

Very high altitude bursts of large yield nuclear weapons may be a feasible way of sterilizing aerosols of the more delicate pathogens such as vegetative cells or viruses. Spores are marginal. For example, a 25 megaton weapon burst at an altitude of 50 km will produce a thermal fluence on the ground of only 10 cal/cm$^2$, but a thermal flux density of 250 cal/sec, cm$^2$. This flux density will heat 100% emissivity 1 micron particles over 30°C and 5 micron particles 400°C.

Lasers are theoretically a far more efficient means of killing biological aerosols due to the much shorter pulses of much higher power that they can deliver. For example, a Q-switched ruby laser delivering one joule in 10 nanoseconds can deliver a thermal flux density of 25,000 cal/sec, cm$^2$ over a square foot. This should be capable of heating to 3000°C one-micron particles with an emissivity of only 10%. Even anthrax spores should not survive this. Experimental verification of the laser capabilities is planned.

## Chapter 9. Washington D. C. Subway

G. A. Cristy

The design phase of the Washington D. C. subway has taken much longer than originally expected. Although final conclusions cannot yet be drawn relative to the feasibility of using the subway as part of a coordinated blast shelter system for the District, the tentative conclusions reported in last years annual report are still valid. Although beset by political and financial problems, the subway could still be completed essentially on schedule.

## Chapter 10. Report of Shock Tube Research During the Period March, 1967 - March, 1968

L. Dresner and C. V. Chester

Studies of shock wave attenuation have been carried out in a four-inch shock tube driven by the detonation of a 21%-79% propane-oxygen mixture. The explosive yield is 6 g TNT per foot of driver length; driver lengths up to 15 feet are available. The shock tube produces air shocks with peak overpressures up to about 450 psi. With these overpressures and yields it is possible to model exposure of an eight-foot tunnel to a 10-mega on groundburst at the 400-psi circle or any less severe exposure.

We have studied the attenuation of shock waves in long pipes by orifice plates, rough walls, and cylindrical obstacles. The studies indicate that the attenuation factor C (the ratio of the static over-pressure after attenuation to the pressure in a smooth pipe) may be correlated with the Fanning friction factor as follows

$$C = \exp(-0.3f\Delta X/D)$$

where f is the Fanning friction factor in the baffled section of pipe, $\Delta X$ is the distance from the beginning of the baffled section to the point of interest, and D is the diameter of the pipe. Such an equation is entirely adequate for engineering design purposes.

## Chapter 11. The Peak Overpressure at the Foot of a Vertical Wall Facing an Air Blast

L. Dresner

Amplification of the peak pressure at the base of a vertical wall is brought about by the simultaneous reflection of the incident shock from the wall and the ground. We have constructed a simple theory for calculating the peak overpressure based on combining the known solutions of the problems of the problems of oblique and normal shock reflection. We have checked this theory with experiments carried out in the shock

tube for angles of incidence of $30^\circ$ and $45^\circ$ and incident overpressures between 50 and 300 psi and found good agreement.

## Chapter 12. Power Reactor Vulnerability to Nuclear Weapons

C. V. Chester and R. O. Chester

A one-hundreth scale model of a nuclear power reactor was tested with conventional explosives designed to give a scaled pressure versus time function equivalent to a 100 KT nuclear weapon detonated at various distances from the reactor vessel.

The results of this preliminary study indicate that power reactors are probably not exceptionally attractive targets for enemy nuclear missile attack. First, the study indicates that power reactors are so resistant to blast damage and delivery accuracy for nuclear weapons is probably sufficiently low that many tens of missiles must be targeted on a reactor to give a 50% chance of rupturing the pressure vessel, and releasing the fission products in the core into the weapon cloud. Second, if the pressure vessel is not ruptured, the release of volatile fission products will occur after the atmospheric effects of the weapon have subsided and hence will be distributed by local meteorological conditions. Most of the radioactivity released from the core should therefore be deposited in the area already badly damaged by nuclear weapons effects and should cause no additional casualties.

# SOCIAL ASPECTS OF CIVIL DEFENSE

## Chapter 13. Strategic Interactions

Davis B. Bobrow

A pilot study of the public communications of the Chinese Communist Party was conducted to test the use of content analysis as a method of measuring the images held by Chinese elite about other countries. From a future expanded analysis we hope to be able to obtain political and

psychological data which would be used with technological and economic factors as a basis for defense policy choices.

The pilot study was conducted with the content of editorial summaries in the People's Daily during fifteen weeks from 1960 through 1964. The individual weeks were selected to represent different event climates: ceremonial, international, and domestic. The results suggested several tentative conclusions. First, most countries in the Middle East, Africa Latin America, Western Europe, the Old Commonwealth, and Eastern Europe receive little attention from Chinese elites, with the exception of the USSR, Algeria, Cuba, Albania, and Rumania. The last four countries may be viewed as those whose policies fragment the sphere of influence of major competitors.

The Soviet Union, Japan and the United States are viewed as competitors and the latter two as enemies. Communist China tends to view Japan as a country which "gets more than it gives" in the international relations, and the USSR and US as countries which engage in more conflictful than cooperative international relationships. It sees itself as both reasonable and cooperative.

Considerable attention is paid by Chinese elites to countries which were within the classic zones of Imperial Chinese interests, suggesting that Communist China may view these nearby countries as potentially within her suzerainty rather than under her direct rule.

## Chapter 14. Responses of Influentials to Negative Contingencies

Sue B. Bobrow

This year a questionnaire and a sample were developed as part of a program to measure the way influential Americans react to a communication about the possibility of a nuclear attack on the United States and alternate ways of handling this possibility. The people whose attitudes will be investigated were selected from authors on nuclear strategy and disarmament who are not now full-time government employees, former government executives in agencies with nuclear weapons policy

responsibilities, and past members of scientific or analytic advisory groups to the same agencies. Both a mailed questionnaire and a three hour taped interview will be used if resources for the project are adequate; otherwise, a larger number of questionnaires will be used alone.

The questionnaire was pre-tested with fourteen individuals at ORNL to try to eliminate confusing instructions, etc. After revision, the response categories were formated for computer key-punching to simplify the analysis of the results. The final questionnaire contains fifty-seven questions, twenty-one of which are multi-item questions. Examples of the questions are included in the body of the report.

## Chapter 15. Public Responses During an International Crisis

Tom Atkinson

An analysis of six public opinion surveys conducted during the U. S. - Sovie confrontation over Berlin in 1961 yielded the following conclusions:

(1) Regardless of international tension level, education is negatively correlated with expectation of war.

(2) Regardless of international tension level, educa [illegible] is positively correlated with a tendency to engage in pers[illegible] vil defense oriented behavior.

(3) During the early stages of a crisis, expectio[illegible] of war is positively correlated with civil defense behavior for high school and college educated groups but the correlation is higher for grade school education groups during the later stages of the crisis.

(4) Civil defense behavior changes resulting from increasing tension levels occur much more quickly for high school and college educated than for grade school educated groups but there are no differences in the groups' expectation of war changes.

(5) Changes in civil defense behavior and expectations of war were in the same direction and of the same magnitude regardless of the group education level.

(6) Changes in civil defense behavior and expectations of war induced by increases in international tension were more enduring the higher the education level of group.

## Chapter 1[illegible]. Generational Trends in American Public Attitudes Toward Active and Passive Defense

Neal E. Cutler

The research reported here represents the first longitudinal efforts to emanate from the national security survey data bank established by the Civil Defense Research Project. The primary focus of the research is to determine the impact of generational factors upon patterns of national security attitudes. The analysis is based upon measurement of the attitudes of three generational groups -- the World War I cohort, the Great Depression cohort, and the Nuclear F[illegible]hort -- toward four national security policy alternatives -- Maintenance of American Military Capability, Non-Military Extension, Military Extension, and Advocacy of War. The national sample surveys involved in the analysis represent the period 1[illegible]-1[illegible].

The analysis demonstrates that the historical circumstances surrounding the socialization of successive generational cohorts do differentially affect the national security attitudes held by members of the cohorts. Across all four question-sets, longitudinal increases were found to have taken place in the support given to the policy alternatives; that is, each alternative was given greater attitudinal support by the most recent generational cohort than by the earliest cohort. Particularly dramatic monotonic increases in support are found in the two "extension" question-sets noted above. The trends in public perceptions and endorsement of national security policies, in other words, are in the direction of increased extension of American resources, both military and economic, to other parts of the world. In terms of the classic isolationist-internationalist type of distinction, these data imply that the American public has become increasingly internationalistic over the 1[illegible]-1[illegible] period.

## Chapter 17. Emergency Preparedness in the Federal Executive Agencies

Claire Nader

The focus of this year's analysis of federal emergency programs is the medical stockpile program. Eight factors accounted for the characteristics of the program, during the period 1951-1967. The were: (1) structural changes in the federal civil defense organization, (2) a limited operational concept of emergency medical care, (3) organizational isolation leading to inadequate communications, (4) inadequate staffing, (5) lack of leadership, (6) legal constraints, (7) resistance to change, and (8) divided responsibility for program surveillance. The program was changed and strengthened by modifications during the period 1963-6. The most important factors which shaped the revised program were : first, an improved system of budget review; second, program content analysis by the Office of Science and Technology: third, the appointment of a task force to help plan the program revisions: and fourth, the appointment of new leadership in the operating agency, the Public Health Service.

## Chapter 18. Vulnerability of Grain Stocks and Food Supplies

A. F. Shinn

Mid-year carryover stocks of grains have generally trended downwards since their peak of 1961, but the available crops in the field at mid-year 1967 taken together with the carryover stocks are judged to be an ample but poorly located supply for emergency use under present defense plans. The national food supply on July 1, 1967, was estimated to be at least 19 months at 3000 calories daily for the total U.S. population. The estimate excluded farm crops in the field. The geographic distribution of the stocks by states is grossly unequal and shows at midyear only a few months supply for some state populations whereas others have many years supply on hand. The concentration of

food stocks in the grain states underscores our dependence upon reliable transportation for their equitable distribution in a nuclear emergency. The National Advisory Commission on Food and Fiber has recommended programs to adjust carryover stocks of major farm commodities and to establish a strategic reserve of farm commodities. Congressional bills to meet these recommendations are quite naturally more concerned with increasing the farm income than with defense needs but the establishment of such a strategic food reserve would be quite beneficial to civil defense. Recent overseas experiences with foot-and-mouth disease have demonstrated the extreme difficulty of coping with a severe biological threat to livestock. Because our livestock is vulnerable, and since lysine-fortified grain would make a good alternate source of protein, it is suggested that lysine logically belongs in a strategic commodity reserve program.

## Chapter 19. Vulnerability of Livestock in the Livestock Industry

S. A. Griffin

As a part of a general study of food resources and vulnerability, we are investigating the present radiation protection which would be provided for livestock in existing farm structures. Few data are in the literature. A cooperative program was established with the Tennessee Office of the Statistical Reporting Service of the U.S. Department of Agriculture, in which all farms normally visited throughout the state to obtain livestock population data were surveyed for livestock protection structure type and feed availability. Half the barns had hay stored above the livestock area and one quarter had inside water supplies. Food under cover during the survey period of November 22 to December 2, 1967 was sufficient for an average of 100 days of livestock feed. Food storage at that time was probably at its peak.

The protection factors presently available range from near unity to 5.4 with an average of 1.8. Thus livestock in Tennessee and probably throughout the U.S. is quite vulnerable to fallout radiation. However,

protection factors in the range of 2-3 can be of significant importance in areas where exposure levels (RBE) of 500 to 1000R would be encountered. An example of the importance of low protection factors is presented using the Tennessee fallout patterns from the UNCLEX attack.

## Chapter 20. Cost of Conventional Food as an Item in a Food Reserve Program

C. D. Garland and J. A. Martin

A food reserve program consisting of conventional foods would be a complex and expensive operation. Numerous problems would occur in the production and maintenance of these stocks. Although the normal channels of trade are capable of functioning as a limited rotational outlet, the economic losses sustained in rotating conventional foods into animal feeds appear to be prohibitive.

A more attractive plan would consist of the use of unconventional food with a possible supplementation of certain conventional food items. Unprocessed or partially processed food based on stored whole grain has the advantages of increased shelf life, flexibility, and reduced cost.

## Chapter 21. Post-attack Economic Policies

D. A. Patterson and J. R. Moore

Assuming survival of a high proportion of people relative to the capital stock the recovery of the economy becomes uncertain. Under these assumed conditions the quality of preattack preparations for survival and recovery becomes crucial and the organization of the postattack economic system becomes an important part of these plans. This latter aspect of the problem can be stated as how best to allocate postattack resources given a severe supply constraint and a need for work incentives. Alternative solutions to this allocative problem are discussed and an unconventional solution, the control of dual bank accounts, is recommended for further intensive analyses and possible use.

# III. CIVIL DEFENSE SYSTEMS ANALYSIS

## 1. BLAST SHELTER SYSTEMS WITH A LIGHT, AREA BALLISTIC MISSILE DEFENSE

R. A. Uher

### 1.1 INTRODUCTION

Since a 'sion[1] has recently been made to deploy a light, area-type ballistic 'ile defense, we have studied the effectiveness of blast shelter sy..ems under the shield of area defense.[2] We used two measures of effectiveness·

1. The number of survivors after the attack.
2. The defense cost exchange rate.

We define the latter measure as the ratio of the cost of the defense to the number of additional offense weapons necessary to negate the life-saving potential of the defense.

We considered two general categories of blast shelter systems. The first category was called non-optimum, which consisted of systems sheltering all people living in densely populated areas to the same blast protection (LD-50 or median lethal ove.pressure). We also assumed that all people not in blast shelters had fallout and thermal protection at no extra cost.

We called the second category of blast shelter systems optimum since at any defense expenditure they were designed to produce the smallest number of fatalities possible at a fixed attack size. The optimum systems are generally characterized by shelters whose blast protection varies with population density with minimum protection being a fallout shelter (assumed to be available at no cost). In both optimum and non-optimum blast shelter system evaluation, we allow the attacks full knowledge of the shelter system and we assume that he always arranges his attack pattern to obtain maximum fatalities.

The next section deals with the description of the kinds of threats used to evaluate the blast shelter systems. In Section [illegible], we discuss the effectiveness of both optimum and non-optimum shelter systems. The major conclusions of the study are outlined in the last section.

## 1.2 THE THREAT

As a result of the U. S. deployment of a light, area ballistic missile defense, we assume that the potential attacker responds by refitting his booster payloads with packages of many 3[illegible]-KT weapons in order to overwhelm the defense. We assume all of his weapons are 100% reliable and fused to burst near the surface. The attacker's objective is the destruction of a maximum number of people which he intends to achieve by targeting his weapons against population centers. Immediate attack warning is ample to obtain full occupancy of a shelter system and at the time of the attack the population is in a residential distribution mode (no evacuation occurs).

We assume that the only benefit of the area defense is to force the attacker to many smaller weapons in order to achieve assured penetration. The area defense is assumed to be unable to destroy a sufficient number of incoming objects to significantly blunt the attack.

## 1.[illegible] COMPARISON OF SYSTEMS

We will discuss the non-optimum blast shelter systems first. Figures 1 and [illegible] show the effectiveness of non-optimum systems for attack sizes of 1[illegible] and [illegible]-KT weapons, respectively. Expected fatalities are plotted as functions of the lowest population density sheltered for several values of the LD-[illegible] overpressure of the system.

The finer lines in Figures 1 and [illegible] are independent of blast shelter systems costs. Using a shelter cost formula[illegible]

$$c = 1\text{[illegible]} + 1\text{[illegible]}\, p_o^{1/\text{[illegible]}} \qquad (1)$$

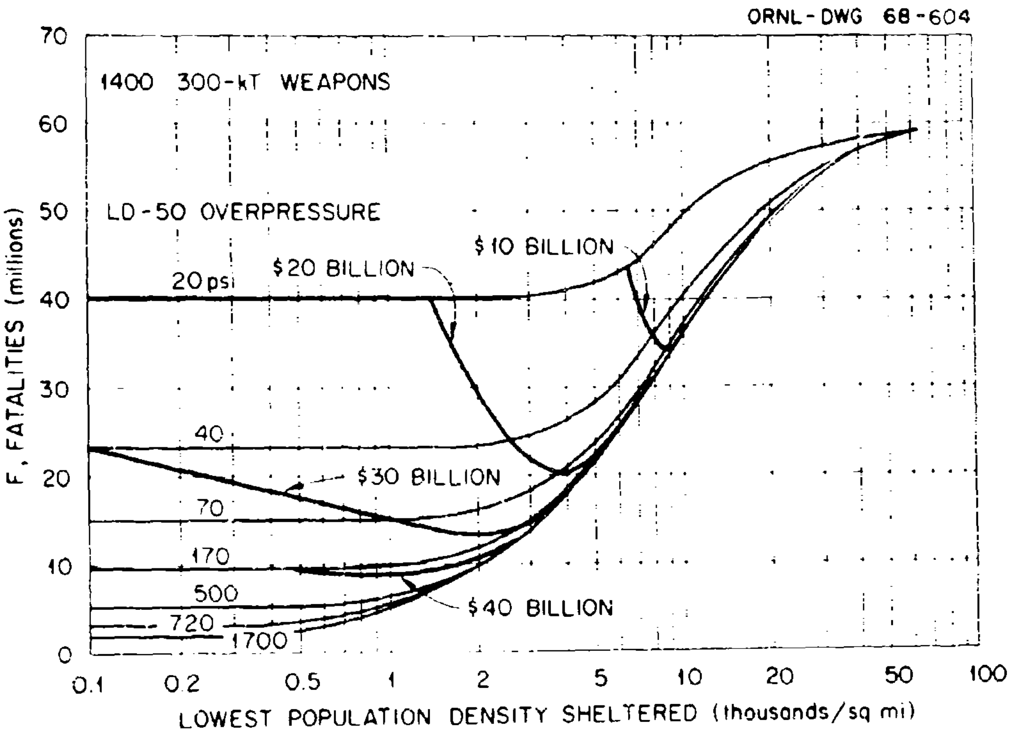


Fig. 1.1. Lowest Population Density Sheltered (thousands/sq mi).

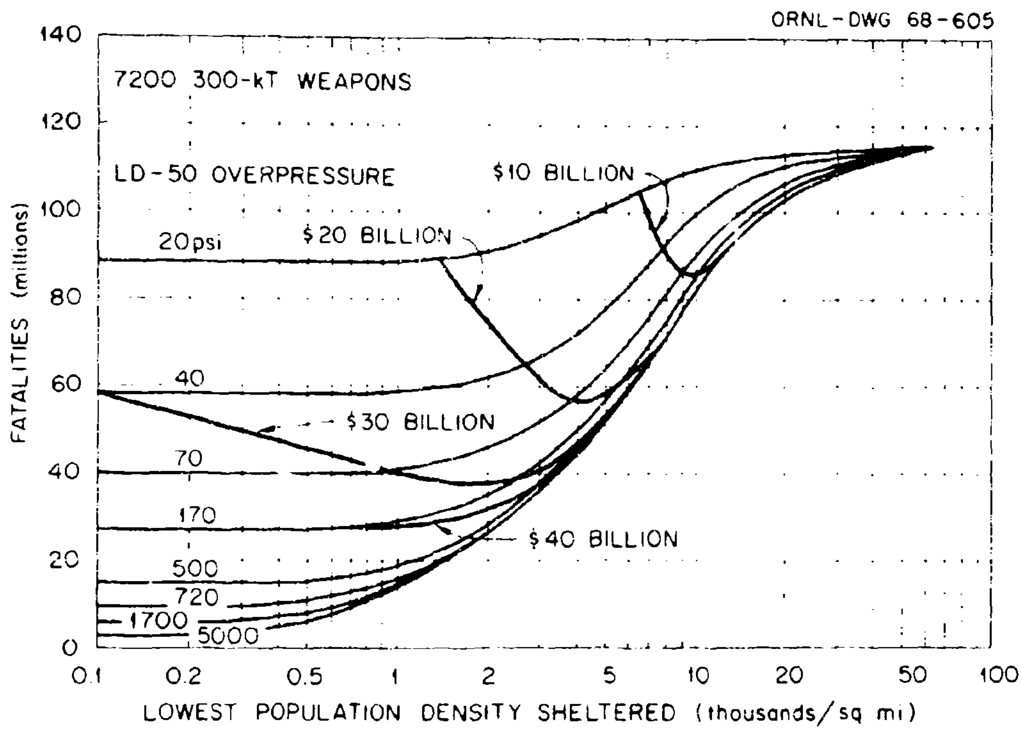


Fig. 1.?. Lowest Population Density Sheltered (thousands/sq mi).

where $p_m$ is the LD-50 overpressure of the shelter and c is the cost per 7.5 sq. ft. shelter space in hundreds of dollars, we have superimposed cost contours (heavy lines) over the effectiveness curves. As the LD-50 overpressure of a fixed cost blast shelter system increases, fewer people receive blast protection. Eventually we reach a point where providing fewer shelters and hardening them more will result in more fatalities. Observation of Figures 1 and 2 shows that for expenditures between 10 and 50 billion dollars, non-optimum shelter systems whose LD-50 overpressures lie in the [illegible]-1[illegible] psi range seem to result in the least number of fatalities for these attack sizes.

In Figures 3 and 4, we show the LD-50 overpressure variation with population density required for optimum blast shelter systems at several attack sizes and two defense budgets, 10 and 50 billion dollars. We used the cost formula given by Equation 1. The figure shows that for larger attack sizes, high population density areas are left unsheltered. In a sense, this is an act of desperation on the part of the defense, who in order to save the most people at a given investment must provide only fallout protection in certain very dense areas.

We had mentioned earlier that optimum blast shelter systems save the most people at a particular defense budget and given attack size. The system chosen does in fact depend strongly on the attack size. In Figure 5, we show the performance of a blast shelter system optimized for a 1,000 weapon attack at a 10 and 50 billion dollar defense expenditure. As a basis for comparison, we also show in the same figure the performance of systems optimized at each attack size for the same expenditures. We can see that at smaller attack sizes, the 10 billion dollar system optimized for 1,000 weapons is ineffective since the attacker can launch an attack optimized against the people in fallout shelters.

In Figure 6, we have shown the performance of systems optimized for 350 weapons against all attack sizes. We see that this system performs very well except at the very large attack sizes.

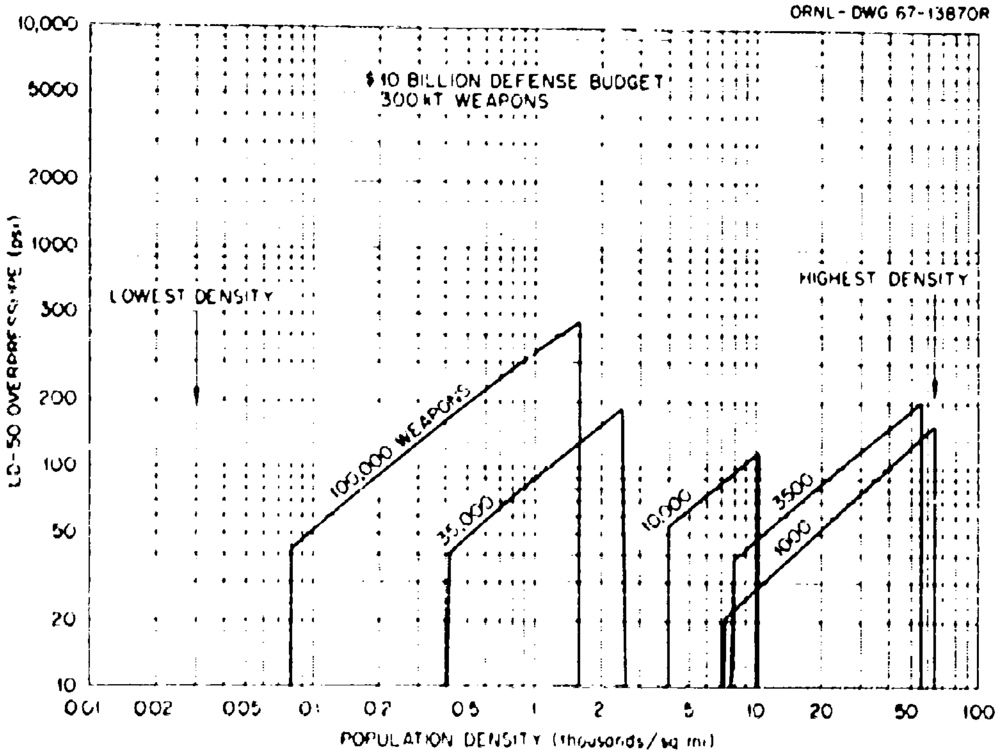


Fig. 1.4. Population Density (thousands/sq mi).

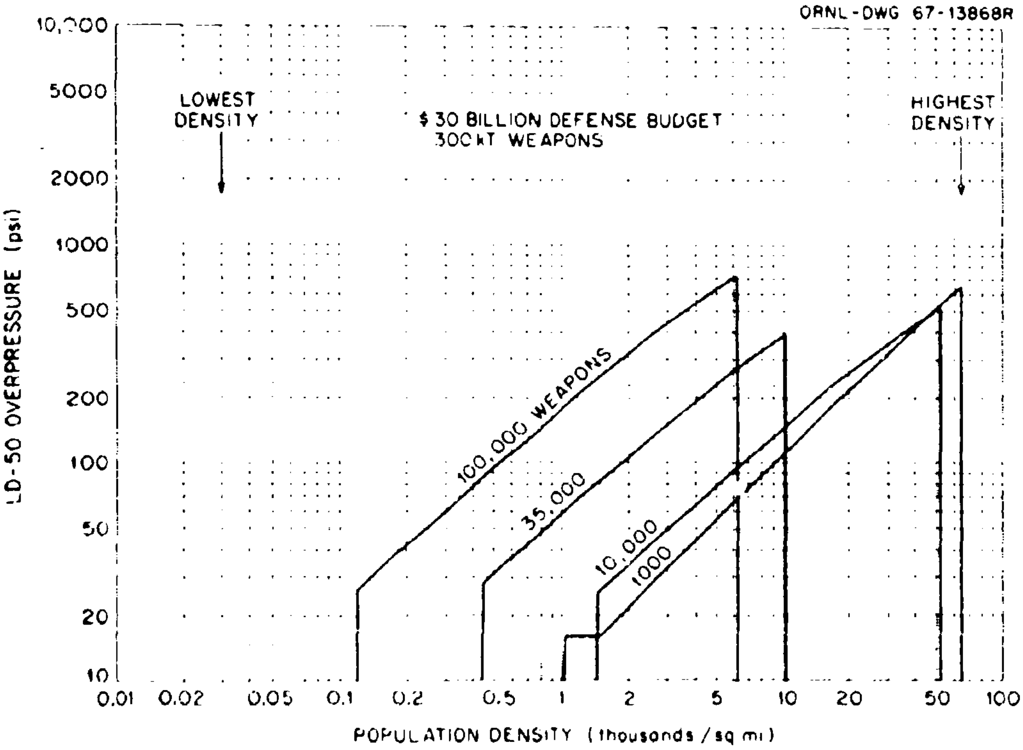


Fig. 1.4. Population Density (thousands/sq mi).

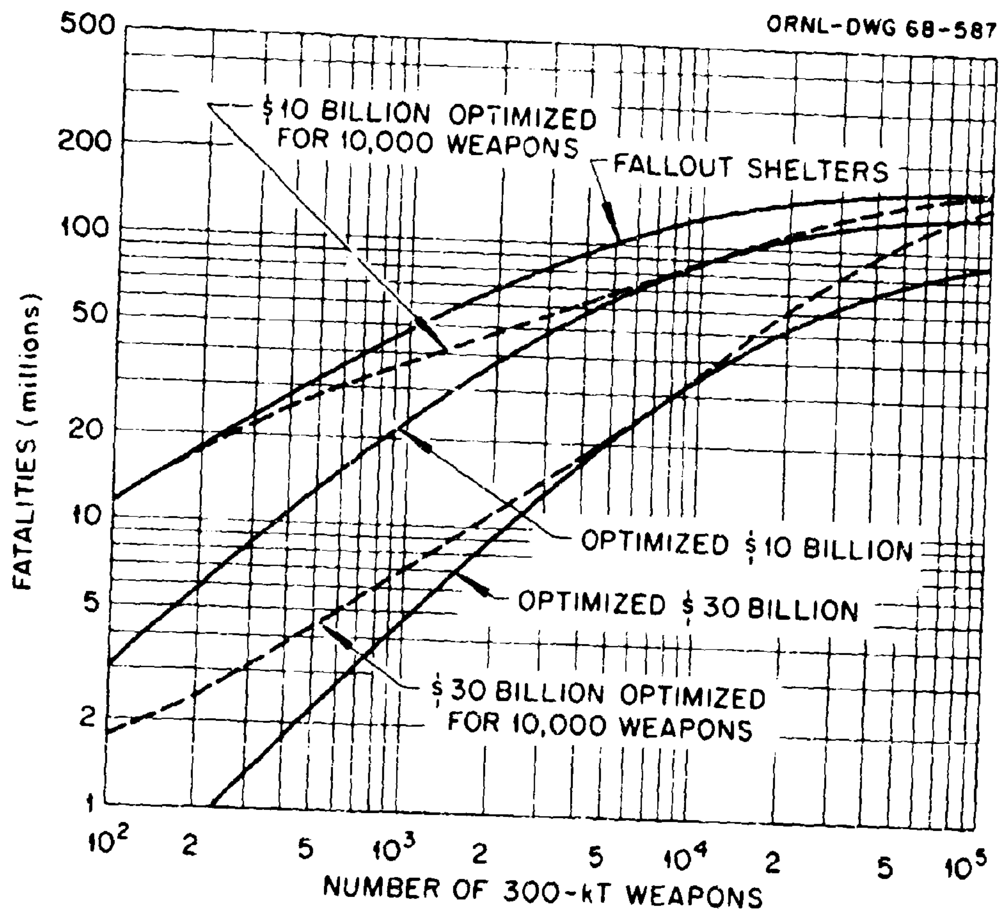


Fig. 1.5. Number of 300-kT Weapons.

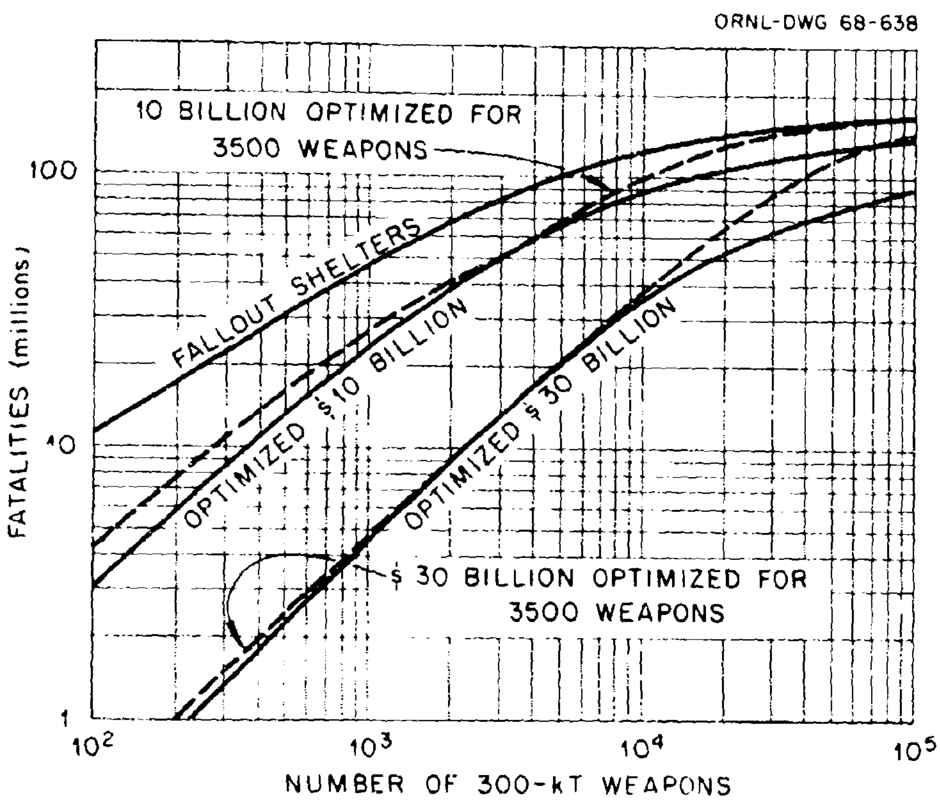


Fig. 1.6. Number of 300-kT Weapons.

In Figure 7, we show the results of optimized attacks against non-optimum blast shelter systems (LD-50 overpressure ~ 10 psi) at 10 and 30 billion dollars. In comparing the non-optimum systems with optimum systems, we see that the 10 billion dollar non-optimum system results in 10-15% more fatalities, while the 30 billion dollar non-optimum system results in 20-40% more fatalities.

The second measure of defense effectiveness used in this study is the defense cost exchange rate. We can write it in the form

$$\frac{\text{Cost of Defense}}{\text{Number of Offense Weapons Needed to Keep Pre-Defense Hostage Level}} .$$

We also refer to this quantity as the defense cost per added offense weapon. If the offense pays more for the weapon than the defense, then we say that the advantage is with the defense. Such reasoning, of course, presupposes that the offense will respond in such a way as to keep the hostage level constant.

In Figure 8, we show the defense cost exchange rate plotted as a function of hostage level for several kinds of optimum and non-optimum systems. To compute the exchange rates for optimum systems, we assume that we know the attacker's hostage level and design the shelter system so that it is optimum at the number of weapons he must use to return the hostage level to the pre-defense value. We have also included two points in the figure which show the effect of optimizing a shelter system to the number of weapons at the pre-defense hostage level and the attacker responds by bringing the level of hostages back to the same value.

Utilization of the life-saving potential of optimum blast shelter systems over non-optimum systems is not without problems. One problem is the estimate of the attack size. A second problem is keeping the shelter system optimum. Changes in population density, attack size and defense strategies may quickly make an optimum system "non-optimum."

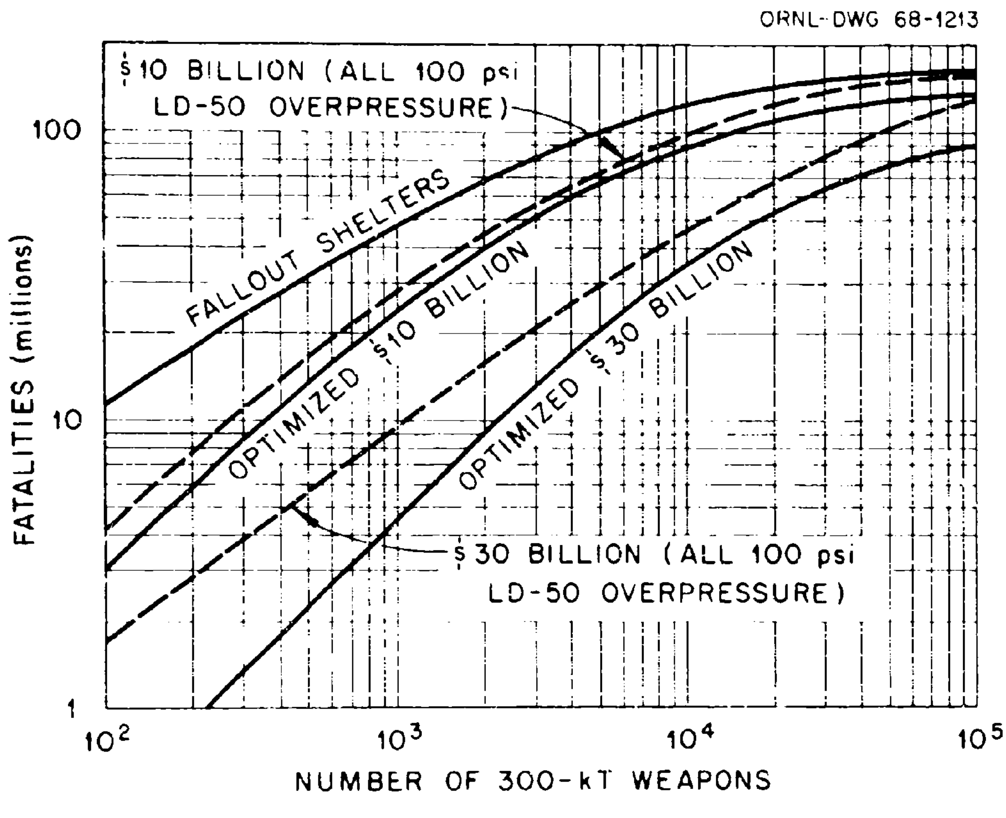


Fig. 1.7. Number of 300-kT Weapons.

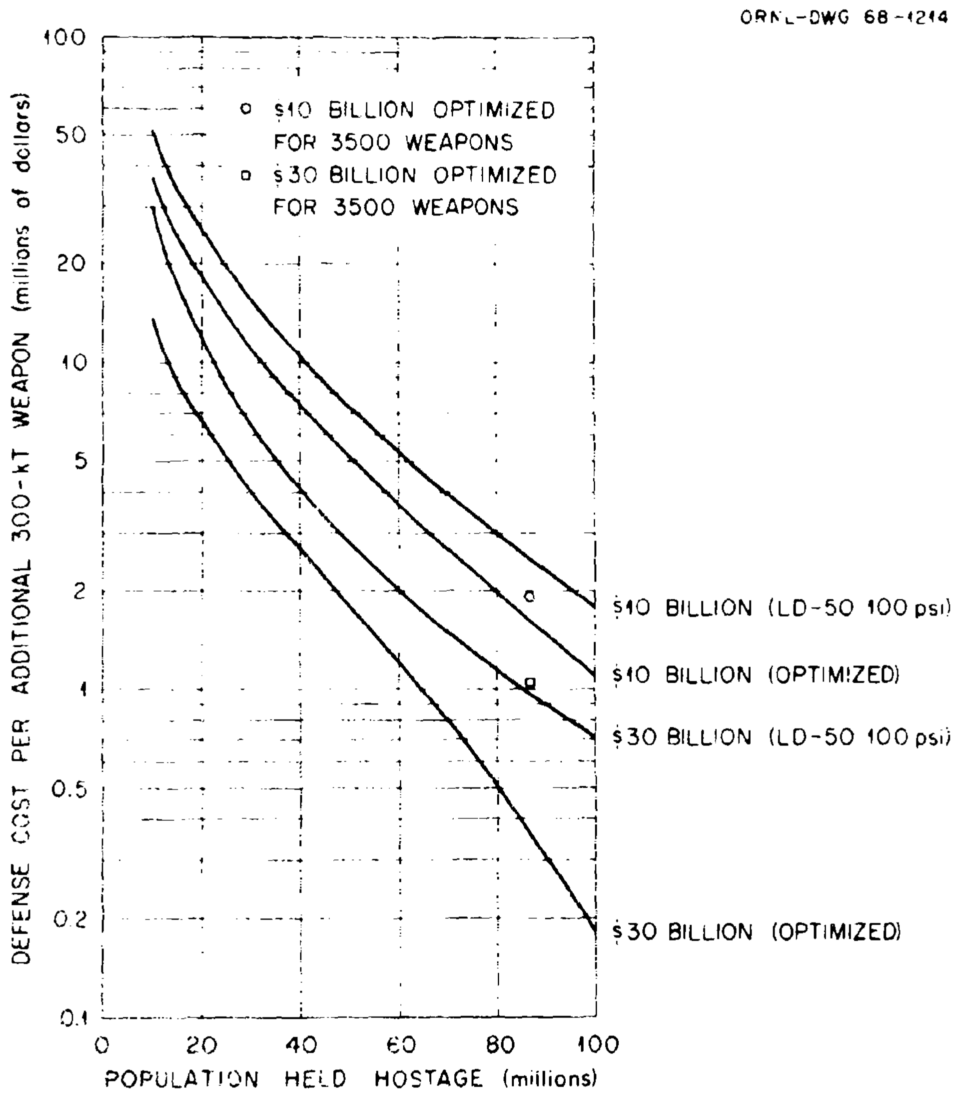


Fig. 1.8. Population Held Hostage (millions).

## 1.4. CONCLUSION

In the evaluation of the effectiveness of blast shelter systems under the shield of area defense, we assumed that the only effect of the defense was to force the attacker to break his payloads into smaller packages in order to penetrate it, which he could then do very easily. We considered two categories of blast shelter systems; non-optimum, in which all people living in high population density areas received the same blast protection and optimum, which were the best systems available in terms of life-saving potential for the defense budget and attack size.

In the study of non-optimum systems, we found that LD-50 overpressures between 80 to 120 psi produced systems which had great life-saving potential for budgets between 10 and 30 billion dollars. When we compared the best non-optimum systems to optimum systems, we found that fatalities were 10-15% higher for non-optimum systems at budgets of 10 billion dollars to 20-40% higher at budgets of 30 billion dollars. Although optimum systems do perform better against any given threat, we feel that the gain in life-saving potential may be counteracted by the cost to make the system flexible enough to respond to changing population density and changing offense and defense concepts. If a decision to deploy a blast shelter system is ever made, flexibility should be considered along with system cost-effectiveness.

## 1.5 REFERENCES


1. Address by Secretary of Defense, Robert S. McNamara to United Press International Editors and Publishers, San Francisco, California, September 1[illegible], 1[illegible].

2. R. A. Uher, "The Role of a Blast Shelter System in Strategic Defense," ORNL-TM-[illegible], Oak Ridge National Laboratory, February, 1[illegible].

# 3. CIVIL DEFENSE SYSTEMS ANALYSIS

C. M. Haaland

## 3.1 ABSTRACT

Three preliminary investigations have been made as a part of a general analysis of civil defense systems. One of the studies presents an overview of civil defense functions and systems by means of Venn diagrams. Another study formulates the problem of the number of people arriving at the shelter entranceways as a function of time in a tactical nuclear attack situation. Separate distribution functions are employed for the warning acquisition time, for reaction time and for the velocity of movement. In another study, a method for calculating the time-distance distribution of linear density of people in a tunnel evacuation system is developed.

## 3.2 INTRODUCTION

A number of preliminary investigations have been made in the process of analysis of civil defense systems. These studies have progressed from a general overview of civil defense down to the specific consideration of blast shelters. The purpose of these investigations has been to find a nation-wide blast shelter deployment scheme which will result in the least number of people killed at least cost to the U. S. for a wide variety of tactical attack situations against the U. S.

In the next section, some general classification of civil defense are made with the aid of Venn diagrams. Then the problem of the estimation of the number of people arriving at blast shelter entranceways is formulated. Finally, a method for calculating the linear density as a function of time and distance is developed for an interconnected blast shelter system.

## 3.3 CLASSIFICATION OF CIVIL DEFENSE

This section describes the construction of a set of Venn diagr which are applied to the operational analysis of civil defense.

Civil defense activities can be generally classified into four phases, namely, preparation, crisis, attack, and operational recovery, with overlaps between the different phases in past, present and future, as shown in Figure 1. In the past, federal civil defense preparation has been continuous, at least since World War II, with and without crisis, indicated by categories [illegible] and 3 in Figure 1. Some local civil defense action has occurred during crisis in the past (e.g., Cuban Missile Crisis) with little preparation, indicated by category 2. In the future, the possible activity categories are indicated by numbers 4 through 1[illegible] in Figure 1. For example, category 1[illegible] indicates a situation in which all phases of civil defense action are occurring, i.e., in some cities not yet attacked, prepared crisis action and some routine non-crisis CD preparation action continues, while in other cities, CD action under attack occurs, and in still other cities, the attack has occurred and CD operational recovery action is taking place.

Diagrams have been considered for indicating the detailed kinds of CD action (such as fire-fighting, rescue, medical care, etc.) and their overlap during each of the above phases of general action. A complete list of actions has been prepared by J. Devaney.[2]

The elements which are defended by the nation are people and property. During a crisis and attack stage, these elements can be further subdivided into six subsets which interact and overlap each other. The six subsets are listed as follows: 1) Threatened property and people; 2) killed people or destroyed property; 3) warned people, or property for which responsible people have been warned; 4) people who act defensively, or property for which immediate defensive action is taken; 5) people in shelters, or hardened property; and 6) actively defended people or property (defended by missile defense, etc.).

The development of a diagram which indicates these subsets and their overlap is shown in Figure 2. In Figure 2a, the square represents the entire U.S. population and property. The circle marked "T" represents the U.S. population and property threatened by an enemy attack. In an active strategic threat, the entire U.S. is threatened. A tactical

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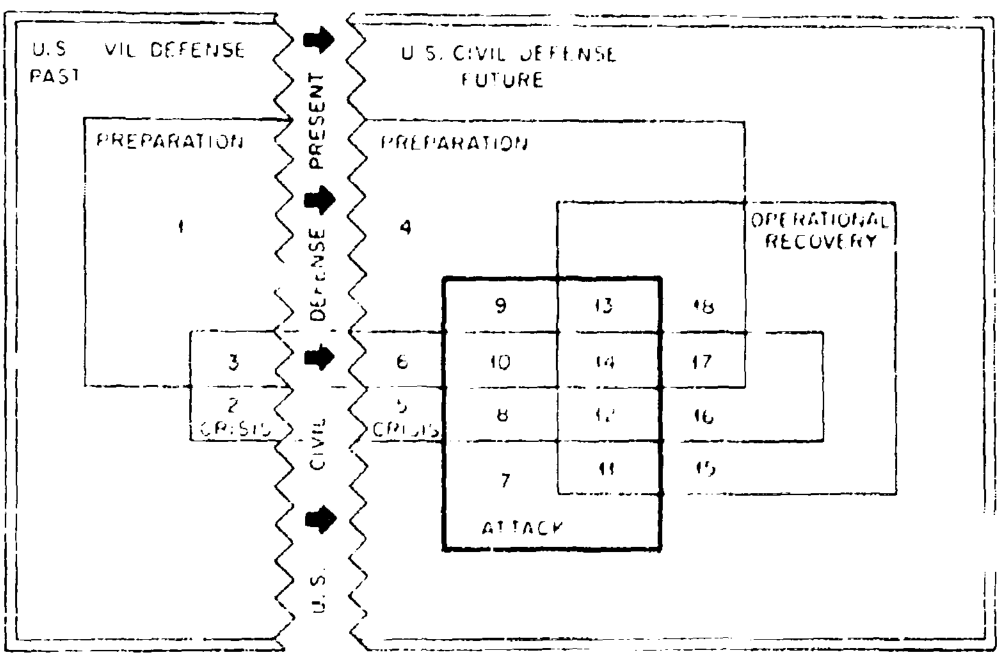


Fig. 3.1. Phases of Civil Defense.

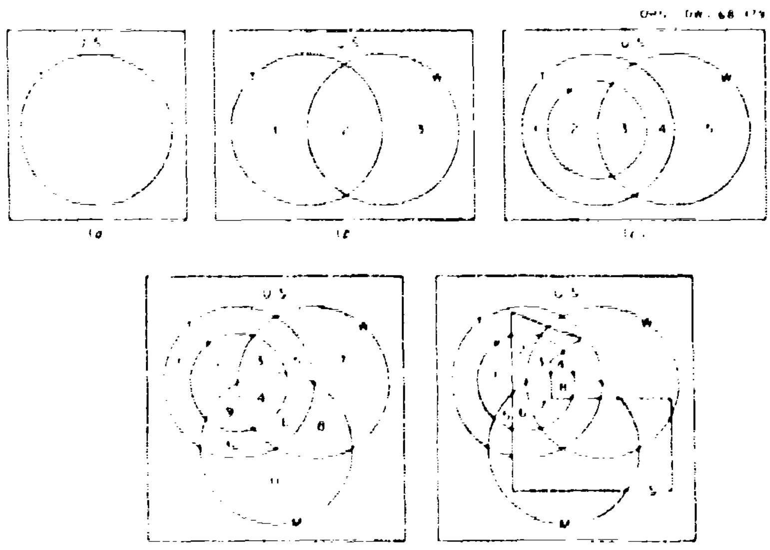

Fig. 3.2. Step-by-step Construction of a Venn Diagram of Sets of Defensive Systems Involved During Attack.

threat covers an area determined by the probabilities involved in the accuracy of prediction of the trajectory of an enemy ICBM by U.S. radar and computers, the probability that the ICBM has post-boost trajectory control and multiple warheads, and the estimated reliability of the ICBM.

In Figure 2b the "T" circle is intersected by the warned ("W") circle. Region 1 represents people and property threatened but not warned, indicated by the symbols T-W. The area of intersection, Region 2, represents people and property both threatened and warned, indicated by the symbols T ∩ W.

In Figure 2c, the "K" circle is added, representing people killed and property destroyed by the threat. It must be contained within the "T" circle because we do not consider people killed or property destroyed by factors other than the threat, such as automobile accidents for example. The "M" circle for moved, or immediate defensive action, is added in Figure 2d, and the "S" area for sheltered people or hardened property is added in Figure 2e. The final diagram including actively defended property and people is shown in Figure 3.

There are several uses for a diagram such as Figure 3. The most important use is the logical separation and overlap of categories which it provides. Another use is to stimulate thought about the actual people and property being categorized. For example, who are in the M-W category, i.e., those who take immediate defensive action without being warned? The answer is: anyone who is moving to a safer position in the usual course of action at the time of threat. A large number of people in this category could result during the evening rush hour in a large city, when hundreds of thousands of people are in traffic moving out of the centers of cities and either do not have access to a radio or do not have it turned on and cannot hear the warning signals through traffic noise.

Another important use of a diagram such as Figure 3 is to aid the construction of indices of effectiveness for the principal sub-systems of defense, i.e., the warning system, the shelter system, and the ABM system. One of the measures of effectiveness of a defense system is the number of survivors relative to the number of people threatened, or (T-K)/T. The number of people killed is divided into 16 categories in Figure 3. An example of the effectiveness of the overall defense system might be indicated by (T-(K S A))/T, which would have the value unity if no one is killed, and

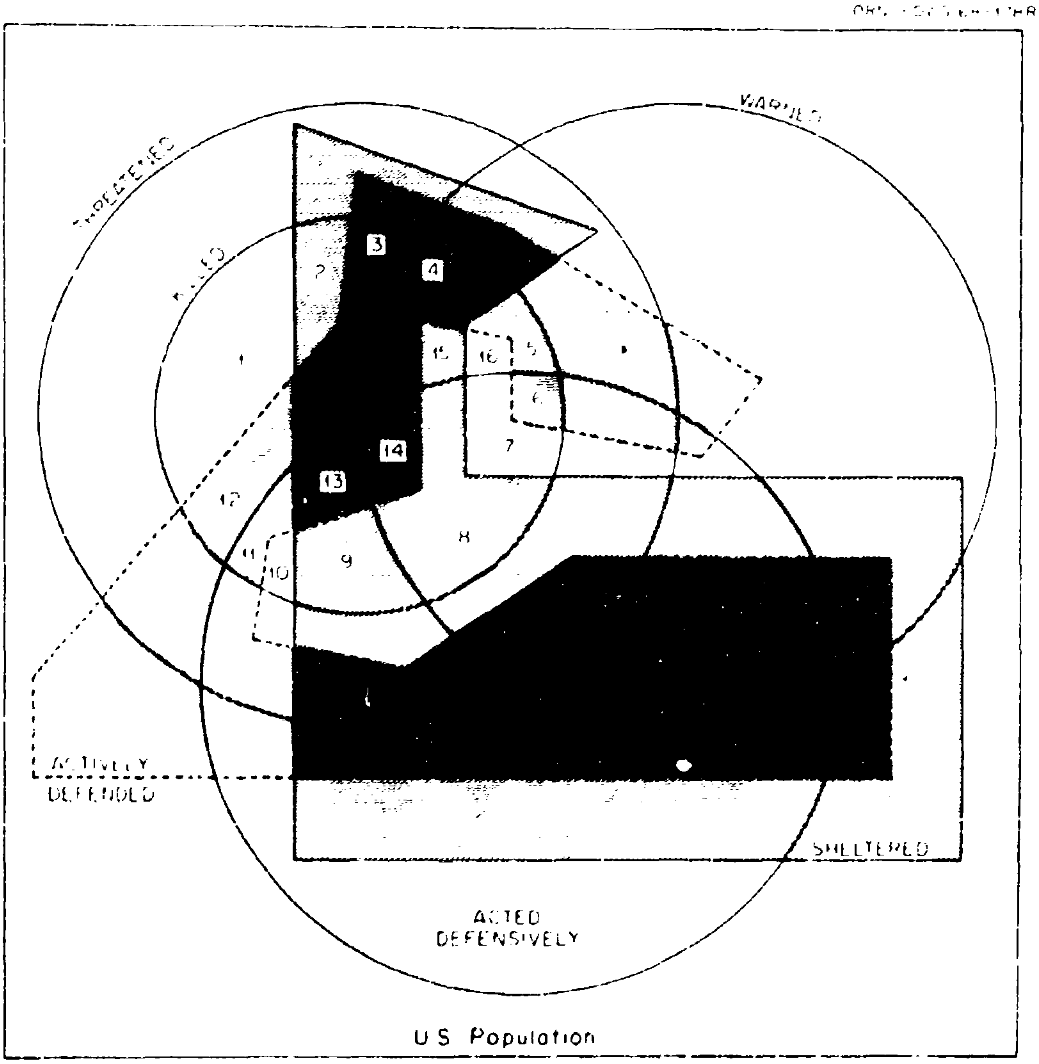


Fig. 3.3. Diagram of Subsets of Property and People during crisis and attack.

zero if (K∩S∩A) = T. The latter condition would exist if K = T, and S∩A = K, or, in other words, if all threatened people are killed, and if all threatened people are defended by shelters and active defense.

Three principal threats may exist during the operational recovery period, namely starvation, disease, and anarchy, and they may overlap. For example, people may be threatened with starvation and/or disease and they may be prevented from getting food and/or medical aid by roving marauders. Also people may be prevented from getting food because of disease, or from getting medical aid because of starvation. These overlaps are shown in Figure 4. For each threat there will be a corresponding warning, action, and attainment of some degree of security from the threat, resulting in nine additional sets. Each of the nineteen categories of people in Figure 4 will overlap in 51 ($2^9$) ways with the nine sets mentioned above, making a total of 9728 categories of people for this system of division for the period of operational recovery. It is obvious that considerable simplification would be necessary to provide overall effectiveness calculations, and the Venn diagram provides a convenient checklist for this purpose.

### 3.4 WARNING, REACTION AND MOVEMENT TO SHELTER IN A TACTICAL SITUATION (see classified supplement*)

### 3.5 FLOW OF PEOPLE IN TUNNELS

One blast-shelter system which is being considered for this study of optimum nationwide deployment of blast shelters is an interconnected system.[6] We assume for this study that after warning, people first move to the nearest shelter entrance on the surface and then move to the nearest city border by way of tunnels. Outside the city they may dwell in fallout or blast shelters throughout the period of hazard.

The tunnels should be designed to provide room for everyone who enters. No one should have to stand outside the entrance in an exposed position waiting until the traffic in the tunnel thins enough to enter. The number of parallel walkways in the tunnel must be adequate to handle the peak flow density resulting from the addition of people through

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*Annual Progress Report, Civil Defense Research Project, March 1967-March 1968, ORNL-4284, Part II (Formerly Restricted Data, Classified).

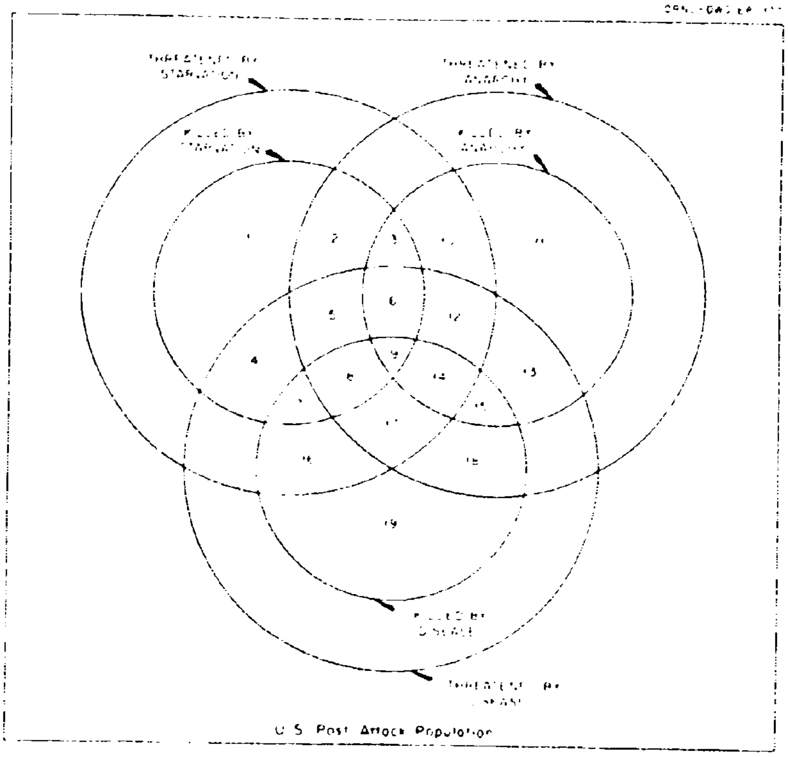


Fig. 3.4. Diagram of Sets of Threats to Life During Operational Recovery After Attack.

entranceways to an existing stream. The system is not analogous to the flow of air in a duct or with water in a pipe or river with contributaries, because the velocity of flow of people is virtually independent of the "pressure", and in fact, may vary with the pressure to some small negative power.

In order to understand these problems we began our studies with a simplified case. We assumed that the people move with a single velocity v both in and out of the tunnels, they maintain constant spacing (fixed linear density) in the tunnels, and that entranceways are located continuously along the tunnels. When the warning signal is given, all people simultaneously begin to move with velocity v, each on a line perpendicular to the nearest tunnel. When a person arrives at the tunnel he enters at that point, makes a 90$^\circ$ turn, and moves along the tunnel without interrupting the flow in any way. His velocity in the tunnel remains constant until he arrives at the dwelling shelter.

One of the simplest cases to consider is a square city with side of length 3d, with uniform population density, and with two North-South and two East-West tunnels leading to dwelling shelters outside the city as shown in Figure 5a. In Figure 5b, the city is divided into regions corresponding to the direction people walk to reach the nearest tunnel shelter, shown by arrows. It is evident from examining the drawing that the city consists of eight similar evaucation patterns, namely, the triangles inside the corner squares, each with an "L" shaped segment of tunnel. One of these patterns is extracted from the city and shown in Figure 6a. The pattern in 6b is equivalent.

There are three basic shapes of evacuation areas in Figure 5b. Two are right triangles, one with its vertex at the left, one with its vertex at the right, and the third is a square. The buildup of the linear density in the tunnel as a function of time can be obtained for any one of these shapes by dividing the area into strips of infinitesimal width parallel to the tunnel. When the people in the n'th strip reach the tunnel, the people in the (n-1) strip have advanced $\Delta d$ down the tunnel, where $\Delta d$ is the infinitesimal width of the strip, and the people in the closest strip have advanced $n\Delta d$ down the tunnel.

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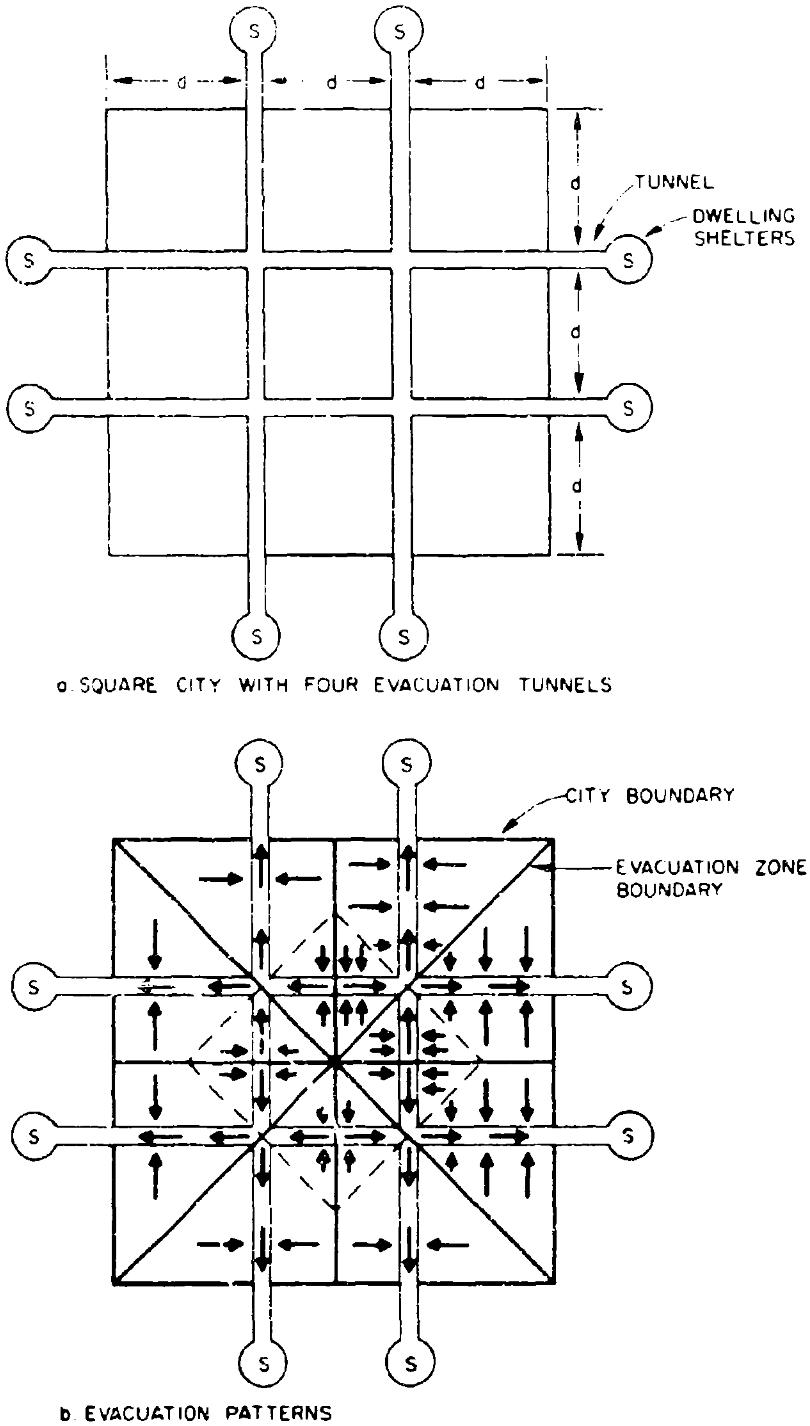


Fig. 3.5. Square City with Side of Length 3d.

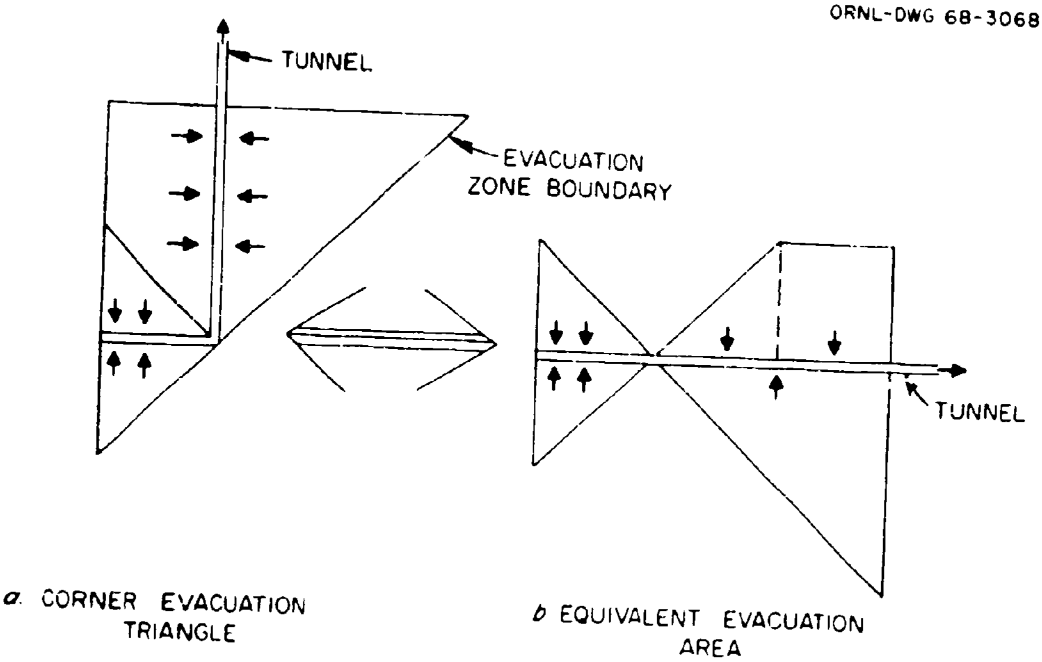


Fig. 3.6. Triangular evacuation portion.

Graphical solutions for the linear densities in the tunnels for the three evacuation area shapes are shown in Figures 7-9. A "Density Generating Area" (DGA) is constructed by a topological transformation in which the evacuation area is first rotated $180^{\circ}$ around the tunnel as the axis, and then each point is transformed in the (-x) direction by a distance equal to its (-y) location. If the evacuation area and tunnel velocities are different, i.e., if the average velocity in the tunnel is $v_T$, and the average velocity in the evacuation area is $v_E$, then the transformation of each point in the (-x) direction is equal to $v_T y/v_E$. If the DGA is now moved parallel to the line $y = v_T x/V_E$ such that the velocity in the x direction is $v_T$, then the linear density $\rho_L(x,t)$ in the tunnel at any position x and time t is given by the product of the evacuation area population density, $\rho$, and the width in the y direction at that time of the portion of the DGA which projects above the line $y = 0$, or

$$\rho_L(x,t) = \rho(y_2(x,t) - H(y_1)\, y_1(x,t))_{DGA} \qquad (12)$$

where $H(y_1)$ is the Heaviside function such that $H(y_1) = 1$ for $y_1 > 0$, and $H(y_1) = 0$ for $y_1 \leq 0$, $y_2$ is the upper bound of the DGA at $(x,t)$ and $y_1$ is the lower.

The solution for $\rho_L$ for the triangular evacuation portion in Figure 6 is obtained by superposition of the three solutions in Figures 7-9, with the result illustrated in Figure 10. Under the assumptions given, the rate at which people flow into any one of the dwelling shelters of the city in Figure 5 will be given by $\rho_L v_T$, where $\rho_L$ is the ordinate of the curve in Figure 10 at a position $x_s$, the location of the entrance to the dwelling shelter, as the curve moves past that position in the positive x direction with velocity $v_T$.

The smallest model rectangular city which contains all possible shapes of evacuation is a square city with side of length 6d, as shown in Figure 11. The three basic evacuation shapes are the corners, the center corridors and the interior corridors. The corners are identical with the four squares in Figure 5b. The graphs of the linear densities

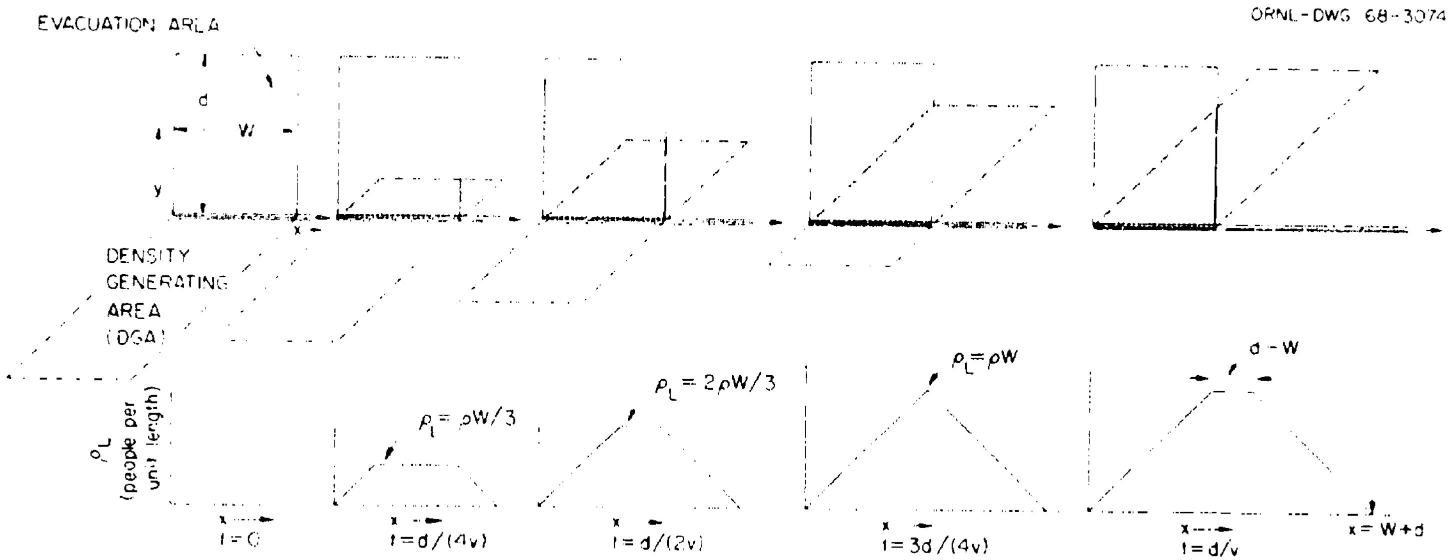


Fig. 3.7. Linear Density Tunnel from Rectangular Evacuation Area.

Fig. 4.5. Linear Density in Tunnel from Right Triangle Evacuation Area, Vertex at Left.

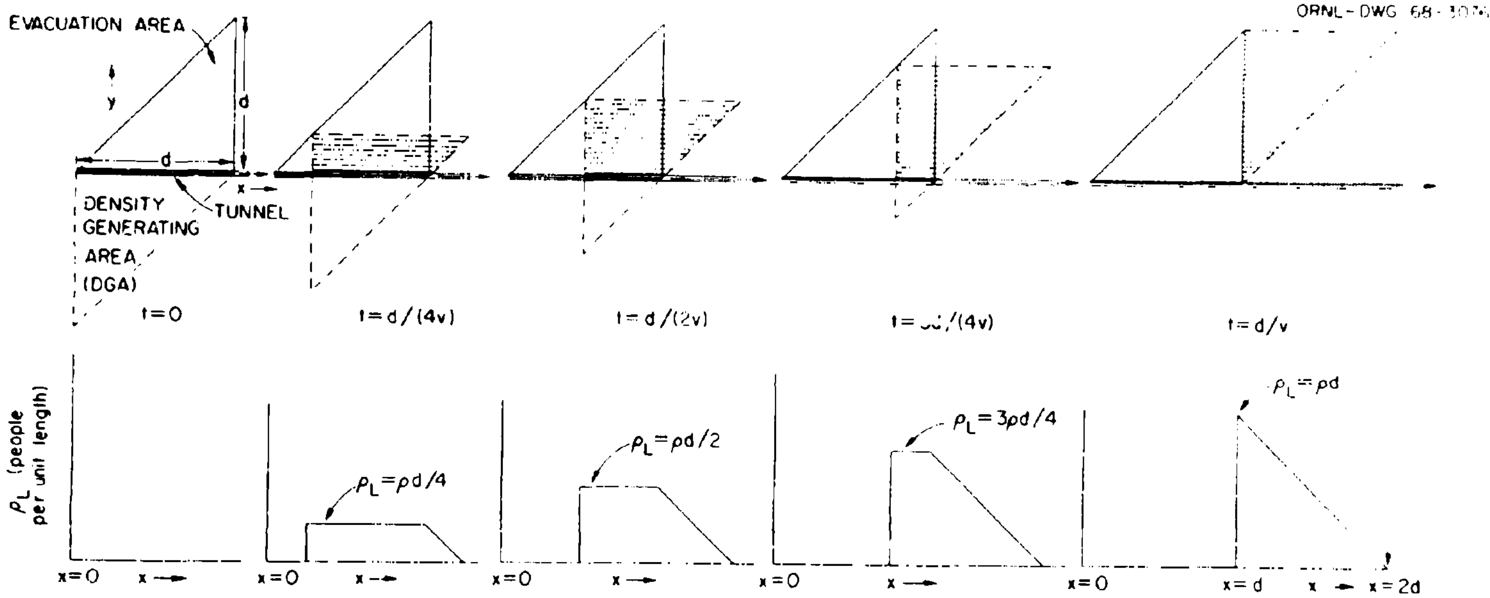


Fig. 3.9. Linear Density in Tunnel from Right Triangle Evacuation Area, Vertex at Right.

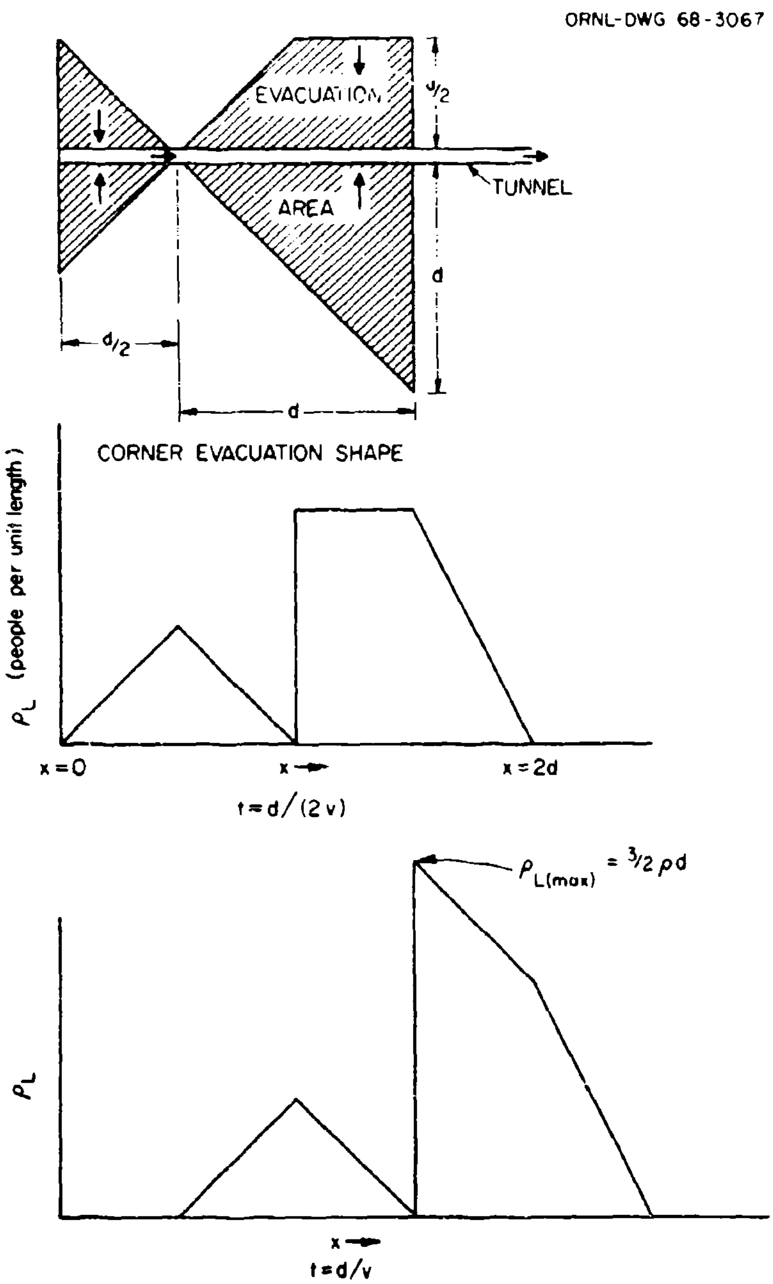


Fig. 3.10. Linear Density in Tunnels for Triangular Evacuation Area of Fig. 5.

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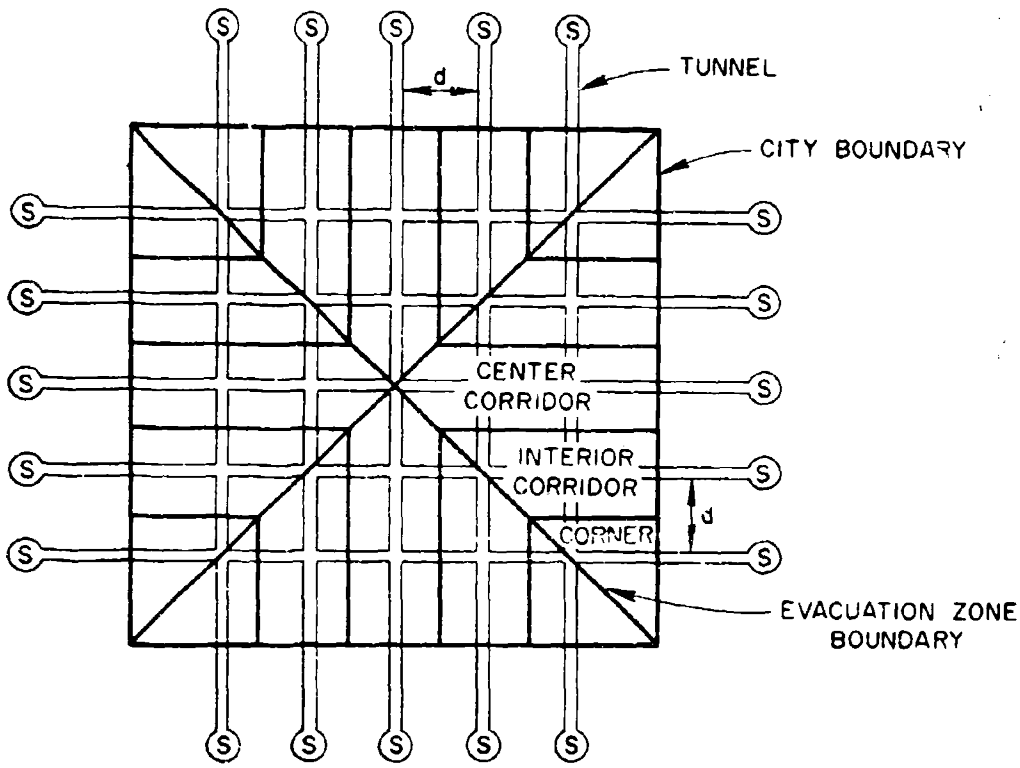


Fig. 3.11. Square City with Side of Length 6d.

in the tunnels for center and interior corridors are shown in Figures 12 and 13, respectively. These graphs exhibit a transient at the front (right) end followed by a number of identical patterns. For a large city ($n \geq 10$), the number of these patterns will far exceed the number of transient patterns. The average linear density in the tunnels when all people have reached them is then $\bar{\rho}_T = \rho d$, where $\rho$ is the population density of the city, and d is the spacing between tunnels.

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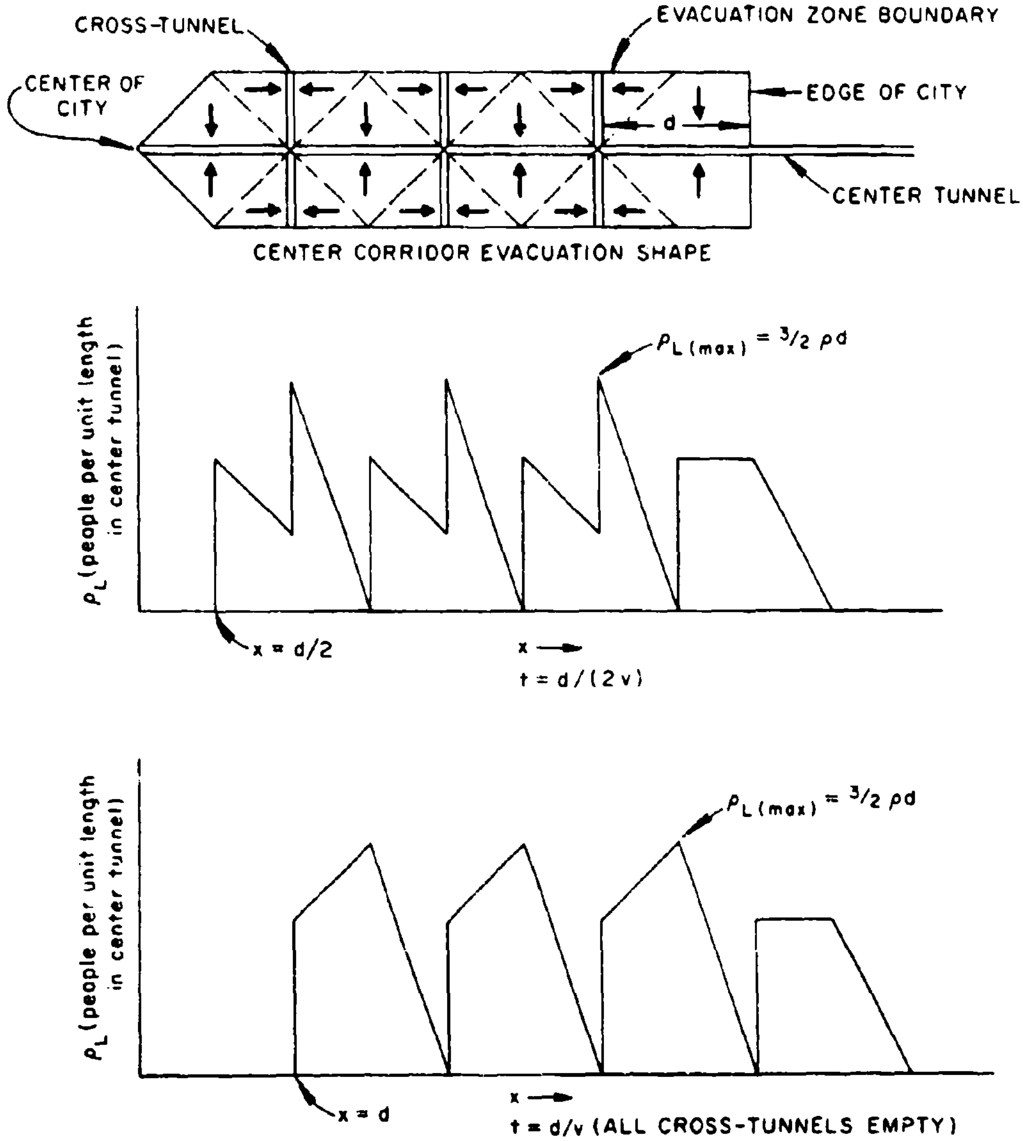


Fig. 3.12. Center Corridor Evacuation.

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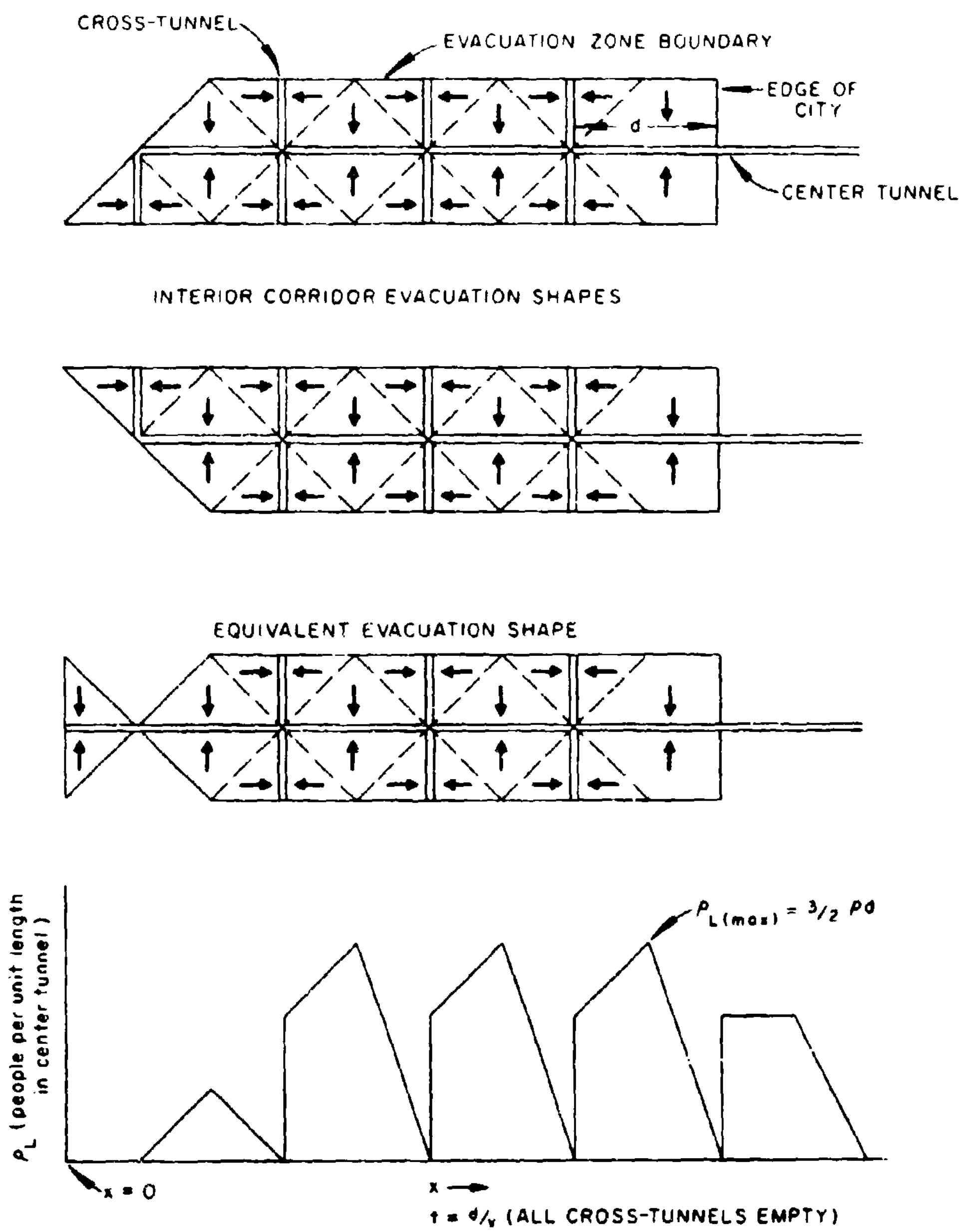


Fig. 3.13. Interior Corridor Evacuation.

## 3.6 REFERENCES

1. Emanuel Parzen, Modern Probability Theory and Its Applications, (John Wiley & Sons, 1960) p. 14.

2. John F. Devaney, Research Directorate, Office of Civil Defense, Civil Defense Research Analysis, Research Report No. 11, December 15, 1966.

3. Robert L. Lamoureaux, Warning Considerations for the Detroit Tunnel-Grid Blast Shelter Concept, March 1967, ORNL-TM-1719.

4. W. A. Hamberg, A. M. Salee, and R. H. Watkins, Study of Tactical Movement Concepts and Procedures for Civil Defense Planning, August 31, 1963, Operations Research Incorporated.

5. 1960 Population of the United States by 5-Kilometer Quadrangles, Stanford Research Institute, Missile Defense Analysis Project, Revised Edition, August 1965.

6. Donald T. Robbins and David L. Narver, Jr., Engineering Study for Tunnel-Grid Blast Shelter Concept for a Portion of City of Detroit, Michigan, Holmes and Narver Inc., October 1965, ORNL-TM-1223.

# 4. PREPARING FOR A CIVIL DEFENSE RESEARCH INFORMATION CENTER: AN EMPIRICAL APPROACH

Joanne S. Levey

## 4.1 INTRODUCTION

The purpose of this study is to prepare the way for an information center on civil defense research information and to determine the shape of the future center: its scope, purposes, services and methods. The approach has been:

(1) to test one method of information handling which would provide subject handles for retrieving documents;[1]

(2) to explore existing sources of civil defense research information by seeking specific information in answer to the needs of individual staff members;

(3) to get an indication of the scope of civil defense research by analyzing the content of current research programs and the rate of literature published as a result of this research;

(4) to gain insight into the current information resources, information barriers, and information requirements of civil defense researchers by conducting in-depth interviews with the interdisciplinary staff of the Civil Defense Research Project; and

(5) on the basis of the results of the foregoing, to indicate the kind of research information center that could best serve the needs of the civil defense research community.

## 4.2 INDEXES TO DOCUMENTS ON CIVIL DEFENSE

Three issues of Indexes to Documents on Civil Defense have been published - two[2,3] to the unclassified reports and one[4] to the classified reports in the Civil Defense Research Library. Each issue contains four indexes to approximately 700 documents: (1) a Bibliographic Index, in which the reports are listed according to the COSATI* subject fields and groups,[5] (2) a Key Word Index (KWIC) which lists every report under each

*Committee on Scientific and Technical Information of the Federal Council on Science and Technology.

significant word in the title and under each descriptor by which the title has been extended, (3) a Corporate Author Index, and (4) an Author Index. The second two issues of Indexes in the series are provided with a fifth index, which lists the documents in them by report numbers. Of these five indexes it is the KWIC Index which shows at a glance all the documents on a given subject in the Index and makes it possible to select these reports from the shelves on request.

## 4.3. EXPLORATION OF EXISTING SOURCES OF CIVIL DEFENSE INFORMATION

### 4.3.1 Introduction

Another way of preparing for a future center has been to explore present sources of civil defense research information by seeking such information in answer to specific needs of staff members. Three principal routes of exploration were:

(1) asking bench questions by letter and/or telephone to some existing information centers,

(2) requesting bibliographies on specific subjects for staff members, and

(3) seeking contractual information on active research and development in areas of interest pertinent to those of staff members.

Of the three information analysis centers queried (Shock and Vibration Information Center, DASA Information and Analysis Center (DASIAC), and National Center for Radiological Health), the Shock and Vibration Center proved to be the most useful. It has furnished specific references to data on shock isolation and has provided a valuable reference on pressure multiplication in re-entrant corners (the increase in pressure at the bottom of a wall compared with the middle).

### 4.3.2 Bibliographies

Fifty bibliographies were requested from the Defense Documentation Center. In each instance the requests were structured as explicitly as possible so that as many relevant reports as were available would be

cited. The range of subject of the fifty bibliographies was broad, including such diverse topics as food storage life, shock isolation, rapid excavation, electromagnetic pulse, postattack demography, and petroleum industry vulnerability. At this time not all bibliographies have been received and evaluated. However, enough have been used to indicate their pertinence and value. For example: on the effects of nuclear attack on food, 5[illegible] references were furnished and 1[illegible] documents ordered; on the effects of nuclear warfare on transportation, 57 furnished, 31 ordered; on methods of excavation, 19 furnished, 7 ordered; on electromagnetic pulse, 95 furnished, and 21 ordered. While there were some complaints - that the volume of unevaluated information was oppressive and that the document search could have been made with more explicit search terms - the overall indications are that DDC bibliographies furnish very useful references to civil defense researchers in the engineering, physics, and biological fields.

In addition to the fifty DDC bibliographies, fifteen bibliographies were requested from the Atomic Energy Commission's Division of Technical Information Extension (DTIE), where computer searches of Volumes 1[illegible] through 21 of <u>Nuclear Science Abstracts</u> (NSA) can now be conducted. The subject headings of <u>NSA</u> were used as a guideline to the kinds of searches that we could reasonably expect to be productive. Some typical examples of bibliographies requested were those on the effects of ionizing radiation on fish, crops, and insects (three separate requests), the vulnerability of livestock to radioactive fallout, and the effects of laser radiation on bacteria.

Two machine searches were requested from the National Aeronautics and Space Administration (NASA), based on the report literature abstracted in its <u>Scientific and Technical Aerospace Reports</u> (STAR) and on the published literature in the <u>International Aerospace Abstracts</u> (IAA). The bibliographies requested were on shock isolation and on shock attenuation in tubes, pipes, and tunnels. The NASA bibliographies were pertinent and useful though less exhaustive than those from DDC on the same subjects.

Twenty-three letters to Science Information Exchange (SIE) were written for resumes of active research and development contracts in specific areas of interest to staff members. The results were varied. We received, for example, notices of 93 research projects on insect pollination of plants, containing an excellent coverage of the current work being done in this field. On the other hand, we received only 6 notices on rapid excavation, much less than the active research in this area would indicate. Seventy notices were sent on the vulnerability of livestock to radioactive fallout, over 200 on the effects of radiation on the storage life of food, and 121 on container and packaging material for food - all representing excellent coverage of these areas of interest. We received eleven notices on shock isolation, five on electromagnetic pulse, one on warning systems, and none on either shock attenuation or the long-term social and psychological adjustments of survivors of a nuclear attack. (It is quite possible that there is little research being conducted in these last two areas.) Contractual information of the same nature as that requested from SIE was also sought from DDC's now automated 1498 Data Bank, which contains resumes received exclusively from DoD and NASA sources. Results of the 1498 search were not available at report time.

### 4.4 THE SCOPE OF CIVIL DEFENSE RESEARCH

As an indication of the scope of civil defense research, it is desirable to find out who is currently doing what research and the rate of literature published. However, it is extremely difficult to make such a determination. First, there is the problem of definition - what civil defense research includes. One way of delimiting the scope of civil defense research is to begin with the civil defense functions which are set forth principally in the Federal Civil Defense Act of 1950, as amended. Executive Order 10952,[6] issued July 20, 1961, assigned many major, but not all, civil defense functions to the Secretary of Defense. The Secretary of Defense delegated these civil defense functions

to the Secretary of the Army, who re-delegated them to the Director of Civil Defense. These responsibilities include the formulation of a national civil defense program which includes measures to warn the population of attack, to protect it both during and after attack and to provide for the recovery of society. Means of carrying out these measures are reflected in the research program areas and projects of the OCD - some undertaken by the OCD staff; most, through contracts with outside research installations. While nine government executive departments and twenty-one independent agencies have emergency preparedness responsibilities, which include, in some cases, research programs, it is the research program of OCD and its contractors that comprises the centerpiece of civil defense research in the United States. Thus, the research information generated by OCD and its research contractors and the information sought by them to accomplish their research objectives constitute the nucleus of civil defense research information.

The most up-to-date work unit listings of research and technology resumes of OCD contractors used in this work were dated June 15, 1966. These 262 resumes show that OCD research was carried on through contract at approximately 35 installations. The locations of the most extensive programs in 1966 were: Stanford Research Institute (39 work units), U.S. Naval Radiological Defense Laboratory (25), Illinois Institute of Technology Research Institute (15), United Research Services (URS) Corporation (11), Institute for Defense Analysis (9), American Institutes for Research (7), and Research Triangle Institute (6). Approximately 150 research reports were generated each year for the past several years from OCD research programs. However, this report rate does not indicate the real extent of the literature which is pertinent to civil defense research. Another index of the number of civil-defense-related reports produced under contracts other than those with OCD is the rate of report accession by the ORNL Civil Defense Research Project. We receive approximately 100 to 150 reports a month, of which approximately 10% derive from OCD contracts.

There is reason to believe that the civil defense report literature has been increasing. Herzog and Jenkins in their Civil Defense Information Systems Analysis[7] have a table showing an "Analysis of Defense Documentation Center Announcement of Civil Defense Related Unclassified Reports" for the six-month period November 1, 1963, through April 15, 1964. Out of approximately 5000 listings, they found 75 unclassified reports relevant to civil defense, of which 29 were produced under OCD contract. That a library serving only about 25 civil defense researchers receives twice as many research reports in one month as were found in TAB in six months four years earlier suggests that the rate of literature pertinent to civil defense research has increased substantially.

## 4.5 THE CURRENT INFORMATION RESOURCES, BARRIERS AND REQUIREMENTS OF A SELECT GROUP OF CIVIL DEFENSE RESEARCHERS

### 4.5.1 Introduction

To gain insight into the current information resources, information barriers, and information requirements of civil defense researchers, an in-depth interview[9] consisting of 21 questions was conducted with 21 staff members of the Civil Defense Research Project. While the CDRP's scope of interest does not cover the entire area of civil defense research, it does have sufficient breadth to be indicative of the civil defense research community.

The educational level of the 21 interviewees is relatively high: thirteen have PhD's; three are doctoral candidates; two have Master of Science degrees; one, a Master of Arts and one, a Bachelor of Science. Further, the disciplines that they represent are diversified. Five are in physics, five in engineering (with two chemical engineers, one civil, one electrical, and one sanitary), eight in the social sciences (with one anthropologist, three economists, three political scientists, and one social psychologist), and three in biological science (one in ecology, one in animal husbandry, and one in agricultural economics). The diversity of project research tasks is conveyed by a sample of key words contributed by staff members to describe their research interests. Under

"S", for example, appear SEWERS, SEX, SHEEP, SHELTERS, SHOCK ISOLATION, SOCIETAL RECOVERY, SOCIOLOGY, SOYBEANS, SURVIVAL, and SYSTEMS ENGINEERING. The program areas represented by staff research include: Systems Analysis, Social Science Research, Federal Emergency Preparedness, Engineering Studies, Weapons Effects, and Postattack Recovery (Table I).

4.5.2 Information Resources

Four questions were designed to get data on information resources of Civil Defense Research staff members: the information centers and/or social science data archives with which they have had previous experience (question 3), the abstract bulletins that they use (question 5), the journals and newspapers they read (question 6), and the specialists in their fields with whom they are familiar (question 15). One question was asked to determine the potential usefulness to civil defense researchers of 111 federally-supported information analysis centers (question 4).

Project staff members had used six information analysis centers and twelve social science date archives (Table II). It is significant that when presented with COSATI's Preliminary Directory of Federally Supported Information Analysis Centers,[9] staff members indicated 42 information centers (Table III) which would be of possible use to them in their work - seven times as many as they were familiar with first-hand.

Project members cited a total of 33 Abstract Bulletins or Indexes (Table IV) which they use regularly to keep abreast in their research field. The inclusion, in the list, of agricultural, biological, chemical engineering, economics, mathematics, physics, psychological, and sociological abstracts underscores the interdisciplinary nature of the Project.

One hundred and sixty five (165) journals and newspapers were cited as being used regularly by project members. That only two of these journals are read by as many as five people, while 105 journals are read by only one person each, points up again the diversity of research interests. A selection of journals which illustrates this breadth is: Air/Water Pollution Report, American Anthropologist, American City, Aviation Weekly, Beef Producer, Endocrinology, Feedstuffs, International Studies.

Information resources for civil defense not covered by abstracts, journals, and direct contact with information centers include (Table V) attendance at scientific meetings and other direct contact with specialists; the Civil Defense Research Library; the Laboratory's Central Research Library; Congressional materials; demand bibliographies; government agencies, departments and bureaus; textbooks; the University of Tennessee - Atomic Energy Commission Agricultural Research Laboratory; special short courses at universities, and, of course, data from experiments performed by the staff members themselves.

The collective information resources of the Project staff members provide insight into how civil defense researchers keep abreast in their field and communicate with one another. They also provide a valuable nucleus of sources of civil defense research information which could be used to direct the newcomer in the field.

#### 4.5.3 Dynamic Information Routes

One question (No. 11) was included to find out how each staff member went about collecting research information for his last task. The answers provided interesting data on the dynamic information routes which some individual scientists follow when they must draw on their customary resources and unearth new ones to begin work on a specific problem. While the dynamic routes were individualistic, some basic patterns did emerge. The following was a frequently cited one:

> Abstracts → journals → articles → bibliographies (at end of articles) → more articles (suggested by bibliographies) → more bibliographies → still more articles.

This process - described as "pyramiding" - is a common one. A variation is to begin with a specialist in the field and to follow his suggestion as to reports to read and other authorities to visit.

Three project members, whose research responsibilities include conducting experiments, begin their research with the card catalogue of the Laboratory's Central Research Library, where they locate basic text books on the subject that they are interested in. Using the card

catalogue as a guide, they carry on an extensive self-education program, progressing from the simple texts to the most comprehensive ones. After mastering the texts, they go either directly to their experimental research (for example, designing and using a shock tube) or to papers and journals and <u>then</u> to their experiment. When asked about the most frequent <u>first</u> source to which they turn in their quest for technical information, eleven staff members - more than half - answered "a colleague," often a colleague in the broad sense - that is, an authority associated with an out-of-town university or installation. The second most frequent first source (cited by five staff members) was their files, and the third, the Civil Defense Research Library (four respondents).

### 4.5.4 Contractual Information

A question (No. 14) was asked to determine Project members' awareness of the active research and development contracts in their area of interest and also the value of such contractual information. Fourteen people indicated that they knew of contracts relevant to their work, nine of these adding, "to some extent." Whether such information is useful seems to be a subjective judgment. Of three social scientists studying reactions of the American public to international events or to alternate U.S. defense postures, one believes that contractual information would be "very useful"; one, "moderately useful," and one, "of doubtful use." Similarly, a researcher on the feasibility of underground utility tunnels and their potential use as blast shelters believes that knowledge of active R & D in this area would be "very useful," while a fellow staff member working on a similar task deems that such information would be "of doubtful use." Thus, while a thoroughgoing scoping study for an information center on civil defense research should include the gathering of contractual information in order to determine the extent of active R & D pertinent to civil defense, a miniature study of twenty-one researchers suggests that not all civil defense researchers would seek this knowledge for their own purposes.

### 4.5.5 Information Barriers

The parts of the interview-questionnaire discussed above pertain to information resources, that is, to how civil defense researchers keep abreast in their field and bring their knowledge to bear on a specific task. Equally illuminating were the responses to the question: What specific problems or problem areas can you point to in your search for information? The most frequently cited problem was the necessity of sifting through enormous quantities of information, much of which is irrelevant or of questionable quality. Again and again the same complaint was voiced, "The utter avalanche of undigested information." To be sure, the gold was in the ore, but right next to it was fool's gold, which looked valuable and proved worthless, or copper, which indeed has value but not when gold is the metal sought. Another barrier to mining the gold was the poor quality of the tools: printed indexes are often either too general or are inaccurate; the search terms in the mechanized retrieval systems are sometimes too gross for civil defense needs, failing to distinguish, for example, betwe : "crops," which are of agricultural importance, and plants, which may or may not be.

Still another frequently voiced complaint was that the lodes containing the gold were too widely scattered, that researchers had to go back and forth between different disciplines to get what they needed. Further, while the research pertinent to their needs usually did exist, it had not been conducted with their problem in mind. An anthropologist finds, for example, that she must go back and forth between the sociological literature and the psychological literature - that the interaction between social and personal properties is not always handy. A specialist in animal husbandry must pull together references from textbooks on biology and agriculture and radiation to determine the vulnerability of livestock to radiation; an agricultural economist finds the information on storage costs organized according to minute categories - kinds of jellies - instead of the broad categories he needs - "fruits," "meats," or "fats and oils."

The foregoing obstructions, though unfortunate, might be said to exist in nature - that is, they are not purposefully erected by any individual or group. Barriers exist, however, which are man-made. In some instances prospectors stake out a claim and zealously guard their holdings from outsiders: there are persons and agencies that have the information, even from government-sponsored research, but for various reasons are reluctant to part with it.

4.5.6 Services Desired from an Information Center

Before considering ways in which an information center might remove the barriers and ease the flow of information, let us examine the attitudes of the Civil Defense Research Project's staff members towards such a center. To the question: Would you use a central source of information and data on civil defense research if it were available to you, nineteen answered "yes" and only two, "no."

When staff members were asked to rank from 1 to 4 the possible services that they would like a civil defense information center to perform for them, "Periodic Abstracts of Current Literature" came first; an "Information Center" and "State-of-the-Art Reports" tied for second and third places; and "Bibliographies" came fourth. Desire for these services stood out well ahead of the other six services which were listed, with eighteen respondents (all but three) selecting "Abstracts" as one of their four choices.

Each staff member was asked to supply both a working question (one he would like to have answered now) and a typical question that he might ask of a civil defense research information center. A sample of the working questions showed that their subject areas include attitudes, vulnerability to blast, costs of building underground transportation systems, propagation of shock waves, packaging materials for foods, emergency health services and plans for the management of resources.

A final question asked to all those interviewed was, "Would you favor a mechanized retrieval system for our document collection?" This question was not tied to any future information center capability but

asked simply in terms of the usefulness of such a measure under our present set-up. It is noteworthy that 19 out of 21 answered affirmatively, four with various qualifications such as "if we have a coincidence system to reduce false drops" or"if we use it for data only" or if we have sufficient documents to justify the cost." Of the two who answered "no," one thought our KWIC Indexes were wholly adequate if sufficiently up-to-date, and one prefers browsing among the actual documents and books to browsing among abstracts furnished by a computer.

## 4.6 A CIVIL DEFENSE RESEARCH INFORMATION CENTER

Before considering the shape of a future center on civil defense research information, it is instructive to quote the definition of an information center provided by COSATI Panel No. 6:

> An information analysis center is a formally structured organizational unit specifically (but not necessarily exclusively) established for the purpose of acquiring, selecting, storing, retrieving, evaluating, analyzing, and synthesizing a body of information and/or data in a clearly defined specialized field or pertaining to a specified mission with the intent of compiling, digesting, repackaging, or otherwise organizing and presenting pertinent information and/or data in a form most authoritative, timely and useful to a society of peers and management.[9]

Keeping this definition in mind, on the basis of the operating experiences of the Civil Defense Research Project and the requirements of its staff for research information, what kind of center would be desirable? It should be indicated at the outset that the establishment of a high quality, fine-grained type of analysis center, such as the kind defined by COSATI Panel No. 6, would be a formidable undertaking. The breadth of civil defense research would seem to indicate not just one but two or three such centers. There could be one, for example, on engineering studies, one on social science research, and one on postattack recovery to include both food production and economic recovery.

In deciding the shape of a civil defense research information center, it is necessary to take cognizance of the nature of the civil defense research enterprise. Its breadth of scope accounts for the diversity of the civil defense research community, and its contingent quality (nuclear war might not occur), for the fluidity of this community. This is to [illegible] that civil defense is not so much a discipline as a mission - that specialists from a wide assortment of disciplines enter it for an indefinite period of time to perform a wide variety of research tasks and then go on to something else. While they are a part of this community, there are services which they can both provide and receive. The combined experience of the ORNL Civil Defense Research Project members - the journals, abstracts, and reports they read; the specialists and information centers with which they have direct contact, and their own research results can furnish a nucleus of information which can be useful to other civil defense researchers. At the same time, a center can provide them with the services for which they indicated a desire in the questionnaire-interview: abstracts, of current literature, bibliographies, state-of-the-art reports, and the existence of a center itself where they can visit and confer with specialists A center could also help to reduce the information barriers, which the staff members mentioned, by collecting, analyzing, and evaluating the report literature for them and by providing sophisticated and sensitive retrieval tools which would pull out only that information that is relevant to their needs.

The operating experiences of the present Civil Defense Research Project have equipped it with a certain amount of know-how in initially directing the civil defense researcher to the information he needs. It can provide him with a subject index to over [illegible] of its own civil defense research reports; it can acquaint him with other information centers which might supply him with data; it can point out reports, abstracts, and journals of possible use to him; it can show him how to get contractual information on current R & D in his field from SIE and from DDC.

However, while all these services are possible, the size of the present staff and the absence of a computer retrieval system severely limit the number of the researchers that the Project can handle. To

serve the civil defense research community, a mechanized retrieval capability is probably called for. If available, this capability could provide bibliographies to users of the Center by descriptor or combinations of descriptors, by author, by installation, and by date. Further, it would be possible for users of the Center to furnish their interest profiles - a few paragraphs describing their specific area of research. Then key words to match the vocabulary stored in the computer could be assigned to each interest profile and the computer queried at regular intervals so that users could be sent those reports pertinent to their research which have been entered into the system since it was last interrogated.

To provide the Center with mechanized retrieval capability might require as long as six months to a year programming time. The Laboratory already has similar computer programs for a number of its information centers; so the programmer's initial job would be to fit our input into an existing format. He could also devise a program which would read the cards that have already been keypunched for the KWIC Indexes and put the information they contain on to the computer in compatible form. If we wanted to retain our capability for producing a KWIC Index, the programmer would have to write still another program, as at present there is none available at ORNL which can produce a KWIC output from the present mechanized retrieval systems used by the Laboratory information centers.

A mechanized retrieval system would make it possible to provide information for large numbers of civil defense researchers; it could not, of course, guarantee the quality of this information. In order to avoid the complaint about the avalanche of undigested information, civil defense researchers - here and possibly at other installations - would have to regularly devote a fraction of their time to analyzing, evaluating, and synthesizing the civil defense research literature. Reports which are either out-of-date or of inferior quality would be removed from the index. Only then could a truly effective information retrieval system be offered to the community.

## 4.7 TABLES

### TABLE I

### Program Areas and Projects of Civil Defense Research Project

#### SYSTEMS ANALYSIS

Civil Defense Systems Analysis: Optimum Allocation of Funds for Blast Shelters to Protect Against an Anti-population Attack

The Role of Blast Shelters in Strategic Defense

The Threat of Electromagnetic Pulse from Nuclear Explosions to Civilian Power Systems

Current State of Tactical Attack Warning Systems

#### SOCIAL SCIENCE RESEARCH

Reactions of Foreign Countries and the American Public to Alternative U.S. Defense Postures and Determinants of their Responses

Responses of American Influentials to the Negative Contingency of Nuclear War

Cohort Analysis of National Security Attitudes (Attitudes of Different Age Groups towards Foreign Policy)

American Public Reaction to International Events

#### FEDERAL EMERGENCY PREPAREDNESS

Emergency Preparedness Organization and Activities of the Federal Executive Agencies

#### ENGINEERING STUDIES

Dual-Use Blast Shelters: Identification of Underground Transportation Structures (Train, Highway, and Subway Tunnels) which have Potential as Blast Shelters

Underground Utility Tunnels: Their Feasibility, Desirability and Potential Use as Shelters

Cost/Benefit Analysis of Underground Utility Tunnels

Equipment Response to Ground Shock

Power Reactor Vulnerability

WEAPONS EFFECTS

Detection of and Protection from Biological Warfare Agents

The Attenuation of Shock Waves in Tunnels

POSTATTACK RECOVERY

Food Production

Grain Supplies and Vulnerability

Vulnerability of Livestock and Salvage of Meat Products

Economic Alternatives in an Emergency Food Reserve Program

Economic Recovery

Economic Requirements for Survival and Recovery

Postattack Economic Organization and Control

TABLE II

INFORMATION ANALYSIS CENTERS AND DATA ARCHIVES PREVIOUSLY USED BY STAFF MEMBERS

Directory of Federally Supported Information Analysis Centers

| Information Analysis Center | Number of Members Who Have Used Center |
|---|---|
| Battelle-Defender Information Analysis Center (BDIAC) | 1 |
| Bureau of the Census | 1 |
| Military Entomology Information Service | 1 |
| Nuclear Safety Information Center | 2 |
| Research Materials Information Center | 1 |
| Shock and Vibration Information Center | 1 |

Social Science Data Archives in the United States
1967

| | |
|---|---|
| Council of Social Science Data Archives | 1 |
| Roper Public Opinion Research Center, Williams College | 3 |
| Inter-University Consortium for Political Research, University of Michigan | 2 |
| International Data Library and Reference Service, Survey Research Center, University of California, Berkeley | 2 |
| M.I.T. Social Science Data Bank | 2 |
| National Opinion Research Center, University of Chicago | 2 |
| Bureau of Applied Social Research, Columbia University | 2 |
| Political Science Research Library, Yale University | 2 |
| Archive on Comparative Political Elites, University of Oregon | 1 |
| Archive on Political Elites in Eastern Europe, University of Pittsburgh | 1 |
| Human Relations Area Files, Yale University | 1 |
| Council for Inter-Societal Studies, Northwestern University | 1 |

TABLE II

(Continued)

| Information Analysis Center | Number of Members Who Have Used Center |
|---|---|
| Miscellaneous | |
| ORNL Instrument Department Information Center | 1 |
| The Biosciences Information Exchange (Smithsonian) | 1 |

TABLE III

INFORMATION ANALYSIS CENTERS OF POSSIBLE USE TO STAFF MEMBERS

Directory of Federally Supported Information Analysis Centers

| Information Analysis Center | Number of Members Expressing Interest |
|---|---|
| Arctic, Desert, Tropic Information Center | 2 |
| Ballistic Missile Radiation Analysis Center | 1 |
| Battelle-Defender Information Analysis Center (BDIAC) | 3 |
| Bureau of the Census | 8 |
| Criticality Data Center | 1 |
| Cultural Information Analysis Center | 3 |
| DASA Information and Analysis Center (DASIAC) | 3 |
| Electronic Properties Information Center (EPIC) | 1 |
| Environmental Technical Applications Center, USAF | 1 |
| ERIC Clearinghouse on Adult Education | 1 |
| ERIC Clearinghouse on Early Childhood Education | 1 |
| ERIC Clearinghouse on Educational Facilities | 1 |
| ERIC Clearinghouse on Educational Media and Technology | 1 |
| ERIC Clearinghouse on the Teaching of Foreign Languages | 1 |
| Fused Salts Information Center | 1 |
| Geodesy Division, C&GS | 1 |
| High Temperature Behavior of Inorganic Salts | 1 |
| Isotopes Information Center | 1 |
| Laboratory Animal Information Center | 1 |
| Liquid Metals Information Center | 1 |
| Military Entomology Information Service | 1 |
| Molten Salts Data Center | 1 |
| National Center for Air Pollution Control | 2 |
| National Center for Educational Statistics | 2 |
| National Center for Health Statistics | 3 |

TABLE III

(Continued)

| Information Analysis Center | Number of Members Expressing Interest |
|---|---|
| National Center for Radiological Health | 3 |
| National Center for Urban and Industrial Health | 2 |
| National Clearinghouse for Mental Health Information | 1 |
| Nuclear Data Project | 1 |
| Nuclear Desalination Information Center | 1 |
| Nuclear Fuel Technology Information Center | 1 |
| Nuclear Safety Information Center | 2 |
| Nuclear Science and Technology Information Service | 2 |
| Office of Economic Opportunity Information Center | 2 |
| Radiation Shielding Information Center | 1 |
| Reactor Physics Constants Center | 1 |
| Remote Area Conflict Information Center (RACIC) | 2 |
| Seismology Division, C&GS | 1 |
| Shock and Vibration Information Center | 4 |
| Shock Wave Data Center | 2 |
| Target Signature Analysis Center | 1 |
| VELA Seismic Information Analysis Center (VESIAC) | 1 |
| **Social Science Data Archives in the United States 1967** | |
| Council of Social Science Data Archives | 1 |
| Roper Public Opinion Research Center, Williams College | 4 |
| Inter-University Consortium for Political Research, University of Michigan | 3 |
| International Data Library and Reference Service, Survey Research Center, University of California, Berkeley | 3 |
| M.I.T. Social Science Data Bank | 2 |
| National Opinion Research Center, University of Chicago | 2 |

TABLE III

(Continued)

| Information Analysis Center | Number of Members Expressing Interest |
|---|---|
| Bureau of Applied Social Research, Columbia University | 2 |
| Political Science Research Library, Yale University | 2 |
| Archive on Comparative Political Elites, University of Oregon | 1 |
| Archive on Political Elites in Eastern Europe, University of Pittsburgh | 1 |
| Human Relations Area Files, Yale University | 1 |
| Council for Inter-Societal Studies, Northwestern University | 1 |
| Miscellaneous | |
| Ohio State Disaster Research Group | 1 |

TABLE IV

ABSTRACTS REGULARLY USED BY STAFF MEMBERS

| Abstract | Number of Staff Members Using Abstract |
| --- | --- |
| Agricultural Index | 1 |
| Animal Breeding Abstracts (British) | 1 |
| Apicultural Abstracts | 1 |
| Arms Control and Disarmament | 1 |
| Asia Foundation Library Notes | 1 |
| Battelle Abstract Bulletin | 2 |
| The Bibliography of Agriculture | 1 |
| Biological Abstracts | 2 |
| Biological and Agricultural Index | 1 |
| Chemical Abstracts | 3 |
| Disarmament and Arms Control | 1 |
| Doctoral Dissertation (Thesis) Abstracts | 1 |
| Engineering Index | 4 |
| Government-Sponsored Research, Department of State, Bureau of Intelligence and Research, Office of External Research | 1 |
| International Periodical Index | 1 |
| International Political Science Abstracts | 4 |
| Journal of Economic Abstracts | 2 |
| LAB Publications | 1 |
| Mathematical Abstracts | 1 |
| Nuclear Science Abstracts (United States Atomic Energy Commission) | 8 |
| Nuitrition Abstracts and Reviews (British) | 1 |
| Peace Research Abstracts | 3 |
| Physics Abstracts | 2 |
| Psychological Abstracts | 4 |
| The Public Affairs Information Index | 1 |

TABLE IV

(Continued)

| Abstract | Number of Staff Members Using Abstract |
| --- | --- |
| Public Health Abstracts | 1 |
| Readers' Guide to Periodical Literature | 1 |
| Referotivni Zhurnal | 1 |
| Review of Applied Entomology | 1 |
| Sociological Abstracts | 4 |
| Solid State Physics | 1 |
| Technical Abstract Bulletin (Defense Documentation Center) | 17 |
| Water Pollution Abstracts | 1 |

TABLE V

INFORMATION RESOURCES NOT COVERED BY ABSTRACTS, JOURNALS, AND DIRECT CONTACT WITH INFORMATION CENTERS

Attendance at meetings and direct contact with

1) other project members,
2) professionals outside of Project but at ORNL,
3) professionals in staff members' own field,
4) specialists outside of staff members' own usual field but having knowledge pertinent to their current research tasks.

Central Research Library

Church of Jesus Christ of the Latter Day Saints (for information on food storage)

Civil Defense Research Library

Card Catalogue
KWIC Indexes
Accessions Lists

Congressional Material

Hearings
Staff Reports

Demand Bibliographies

Nuclear Science Abstracts (USAEC)
Technical Abstract Bulletin (Defense Documentation Center)
Scientific and Technical Aerospace Reports (NASA)
By Project Library Aid

Experimental work of the staff members

General Office of Accounting Reports

Government Agencies, Departments and Bureaus

United States Atomic Energy Commission (USAEC)
United States Department of Agriculture (USDA)
Office of Emergency Planning (OEP)
National Resources Analysis Center (NRAC)
Office of the Interior
Department of Housing and Urban Development
Government Highway Department
Bureau of Commercial Fisheries
Federal Civil Defense Agency Annual Reports
Office of Civil Defense

TABLE V

(Continued)

Information Center Lists and Reports

Installations where activities pertinent to staff research are carried on

ORNL Instrument Department Library

Special (Short) Courses at Universities

Textbooks

University of Tennessee - AEC Agricultural Research Laboratory (UT-AEC-ARL)

## 4.8 REFERENCES


1. For a detailed discussion of the classification and indexing system devised to provide subject handles to the civil defense research reports, see Annual Progress Report, Civil Defense Research Project, March 1966 - March 1967, ORNL-4184, Part I (1967) pp. 181-185.

2. Joanne S. Levey, Ann S. Klein, and Joanne H. Nelson, Indexes to 730 Unclassified Documents on Civil Defense, ORNL-CD-2 (January 1968).

3. Joanne S. Levey, Ann S. Klein, and Bobbie-Jean Hatcher, Indexes to 563 Unclassified Documents on Civil Defense, ORNL-CD-4 (April 1968).

4. Joanne S. Levey, Ann S. Klein, Joanne H. Nelson, and Bobbie-Jean Hatcher, Indexes to 744 Civil Defense Documents (Classified and Unclassified, Limited Distribution), ORNL-CD-3 (April 1968).

5. COSATI Subject Category List (DoD Modified), Defense Documentation Center, Defense Supply Agency, Alexandria, Virginia (1965).

6. Executive Orders Prescribing Emergency Preparedness Responsibilities of the Federal Government, issued by the Executive Office of the President, Office of Emergency Planning, pp. 12-13.

7. W. T. Herzog, and J. E. Jenkins, Civil Defense Information Systems Analysis (A Feasibility Study of Research Information Exchange) (Vol. I), Research Triangle Institute, Durham, North Carolina (1965), Appendix B-17.

8. In preparing the questionnaire for the interview, a particularly useful report was: E. M. Simons, A. W. Lemmon, Jr., R L. Darby, and W. H Veazie, Jr., Report on a Liquid Metals Information Center Scoping Study to United States Atomic Energy Commission Division of Technical Information, Battelle Memorial Institute, Columbus, Ohio (September 1963). This study includes a six-question interview form, from which the following questions were included (after appropriate adaptation to civil defense research) in my questionnaire: (1) Have you had any previous experience with information centers such as the Radiation Effects Information Center, Defense Metals Information Center, Advisory Group on Electronic Parts, or Plastics Technical Evaluation Center? (2) Have you used the MSAR Liquids Metals Technology Abstract Bulletin and/or the Brookhaven High-Temperature Liquid-Metal Technology Review? (4) Rate, from 1 - the most important to 4 - the least important, the possible services which the Liquid Metals Information Center could provide; (5) Would you use a central source of information and data on liquid metals if available to you? (6) List typical questions which you might ask of the Liquid Metals Information Center? pp. 8-12.

9. Preliminary Directory of Federally Supported Information Analysis Centers (not yet ready for publication).

# IV. CIVIL DEFENSE PROTECTIVE SYSTEMS

## 5. DUAL-USE UTILITY TUNNELS

W. J. Boegly, Jr., W. L. Griffith and K. F. Nelson

### 5.1 INTRODUCTION

Results of the survey of present day utility tunnel practices and the preliminary design of a utility tunnel system for the White Plains Central Renewal Area were reported last year.(1) Research this year has been mainly concerned with refining the costs of the White Plains tunnel system, completing a cost-benefit analysis for this system, determining the requirements and costs of auxiliaries for shelter use, and studying new concepts for utility systems which could be includei in future tunnels.

### 5.2 WHITE PLAINS CENTRAL RENEWAL PROJECT

Revisions have been made in the estmated cost of a tunnel system for the Central Renewal Project. More representative costs based on data from White Plains have been used to estimate excavation and tunnel construction costs. Information from the local utility companies has been used to re-estimate utility installation costs by conventional methods, including the cost of the cables and installation. Estimates of the number of power and telephone cables installed in the tunnel for use in the renewal area have also been refined based on information from the utility companies. Costs of cables feeding areas outside the renewal area have been excluded from the cost estimates; however, trays were supplied to meet estimated needs. Based on these changes, the revised cost of a tunnel system for White Plains would be $4,380,000 for the 7,100 feet of tunnels. As reported last year, the

major cost items in the White Plains utility tunnel system are excavation and backfill, and reinforced concrete.

Table I shows the estimated costs of conventional utility systems versus the cost of the equivalent utilities installed in a tunnel. The "savings" shown are basically the reduction in excavation costs for the individual utility systems, since excavation for the tunnel is included in its cost. Thus, it would cost \$3,550,000 more to install a complete utility tunnel system instead of a direct burial system. Operating and maintenance cost for the tunnel system has been estimated to be \$19,000 per year. Of this total, \$16,000 was chargeable to operating costs such as power to operate ventilation fans, heat for the tunnel in extremely cold weather, etc. Heating of the tunnel would be performed with hot water from the central heating plant. Maintenance of the tunnel consists mainly of routine checking and repair of the fans, sump pumps, gas detection system, etc.

## 5.3 WHITE PLAINS TUNNEL: COST-BENEFIT ANALYSIS

A cost-benefit study of the White Plains system has essentially been completed. Where research established that statistics to measure reduced utility operation or maintenance cost and future social costs and benefits were not available, ranges of such costs have been estimated. Consideration of such information shows that, in the absence of budget constraints, a tunnel system might appear economically desirable from the city's viewpoint.

In this study, costs and benefits of conventional underground utility systems have been compared with similar installations in the utility tunnel. The assumptions and capital cost estimates employed in the development of the prototype White Plains tunnel were used (See Table I). For purposes of comparison, capital values have been converted to their annual form (reduction) by assuming an interest cost to the city of 4% and a repayment schedule of 25 years. The study also assumes that the tunnel would be built as part of the

TABLE I Cost Comparison of Utility Tunnel System Versus Equivalent Conventional System for White Plains

| ITEM | CONVENTIONAL UNDERGROUND | INSTALLED IN TUNNEL | SAVING (%) |
| --- | --- | --- | --- |
| POTABLE WATER | 750,000 | 560,000 | 25 |
| NATURAL GAS | 160,000 | 70,000 | 56 |
| HEATING & COOLING SYSTEM | 2,650,000 | 2,250,000 | 27 |
| TELEPHONE SYSTEM* | 380,000 | 250,000 | 34 |
| ELECTRICAL SYSTEM* | 750,000 | 730,000 | 3 |
| COST OF TUNNEL | — | 4,380,000 | |
| TOTALS | 4,690,000 | 8,240,000 | |

*INCLUDES SYSTEM FOR RENEWAL AREA ONLY.

White Plains Central Renewal Project and thus that urban renewal procedures apply. Annual estimates of operation and maintenance costs and social benefits have been made from the available data.

These data have been organized as described in the text and summarized in Table II.* To indicate the incidence of the various costs and benefits and their relevance for decision-making, the various producers and consumers affected by the tunnel system have been listed. The cost and benefits accruing to them are shown in their simplest terms, as the additional cost or benefit incurred with the utility tunnel alternative over conventional burial. Only the capital investment required in each of the two cases has been listed to show the magnitude of expenditure involved.

### 5.3.1 Producers

Item 1. Redevelopment Agency. Under urban renewal procedures, the agency acts as a transfer agent, building the tunnel for the city, and being reimbursed by government grants for its cost.

Item 3. City Services. A saving of $190,000 would be achieved by installation of water lines in the tunnel. On an annual basis, this is shown as a saving of $12,000 for the city, since the city bond issue for water mains would be lower. A measurable benefit to the water department from savings in maintenance, $m_1$, would probably be quite low, since water leaks requiring repairs appear to occur at a rate of about 0.2 breaks per mile per year.** Assuming that city departments should pay rent, $r_1$ indicates the amount of rent the water department would pay per year for use of tunnel space.

Traffic lights, signals, and other city wires would also achieve

*The method of presentation follows Nathaniel Lichfield, "Cost-Benefit Analysis in Urban Redevelopment," Berkeley: University of California Center for Real Estate, 1962, 52 pp.

**Based on statistics from Chicago, Detroit, Philadelphia, and St. Louis.

TABLE II Summary of Cost Benefits

| Item | Producers | Buried Benefit | Buried Cost | Tunnel Benefit | Tunnel Cost | Remarks |
|---|---|---|---|---|---|---|
| 1 | Redevelopment Agency | | | $4380^C$ | $4380^C$ | |
| 3 | City Services | | | | | |
| | Water | | $750^C$ | • | $560^C$ | |
| | | | | $m_1$ | $r_1$ | |
| | Lights (signals) | | | $r_2$ | $r_2$ | |
| | Roads | | | $m_3$ | | |
| | Public Works | | | 19 | 19 | |
| 5 | City of White Plains | | | 12* 38 | 50 | |
| | Tax Revenue | | | $m_4$ | 26 | $m_4$ - 26 |
| 7a | State Government (reduction) | | | | $788^C$ (50) | |
| 7b | Federal Government (reduction) | | | | $2803^C$ (179) | |
| 9 | Private Utilities | | | | | |
| | Electric | | $750^C$ | 3 1 | $730^C$ $r_3$ | |
| | Gas | | $160^C$ | 13 $m_5$ | $70^C$ $r_4$ | |
| | Telephone | | $380^C$ | 19 0.3 | $250^C$ $r_5$ | |
| | Heating and Cooling | | $2650^C$ | [illegible] | [illegible] $r_6$ | Sum $r_n$ 19 + 38 |

| Item | Consumers | Buried Benefit | Buried Cost | Tunnel Benefit | Tunnel Cost | Remarks |
|---|---|---|---|---|---|---|
| 2 | Redevelopment Agency | | | | | |
| 4 | City Users | | | | | |
| | Motorists | | | $m_6$ | | |
| | Pedestrians | | | $i_1$ | | |
| | Utilities | | | $i_2$ | | |
| 6 | White Plains Citizens | | | | | |
| | New Site Occupiers | | | $i_3$, $i_4$ $m_7$ $i_5$ | $p_1$ | $i_5$ + $p_1$ |
| 8 | Nation as a Whole | | | $i_6$ | | |
| 10 | Utility Consumers | | | $m_8$ | | |

Notes
1. C denotes a capital item, all other figures are annual or continuing items and show differences between conventional burial of utilities and installation in the tunnel system.
2. All figures are in thousands of dollars.
3. $m_i$ shows an annual cost item which is measurable in money but has not been estimated.
4. $p_i$ shows in the same way an item which is measurable in physical terms.
5. $i_i$ shows an intangible (nonmeasurable) item.
6. No negative items are shown, a negative cost is considered a benefit and a negative benefit a cost.
7. $r_i$ denotes an annual rent paid by a tunnel user to the city.

* The annual capital savings of $12,000 resulting from the lower initial investment in waterworks in the tunnel are shown as accruing to the city of White Plains rather than the water department.

a measurable saving, $m_2$, from easier maintenance. They will pay rent, $r_2$, as well.

A benefit, $m_3$, is listed for roads, because of the access to distribution lines provided by the tunnel. This means that there should be fewer road cuts and thus less need for repaving. Although measurable, no figure could be assigned, but the benefit would probably be small.

Assuming that the Department of Public Works will be responsible for the operation and maintenance of the tunnel system, Table II shows $19,000 in both the benefit and cost columns, reflecting the yearly cost of operating the tunnel which would be recovered in full from the department's share of utility rents.

Item 5. City of White Plains. The city's share of the cost of the tunnel system under urban renewal, if the whole cost were judged an eligible project expense would be $788,000, and is shown as a cost of $50,000 annually. The city however, from reduced capital investment in the water system, also receives the equivalent of $12,000 yearly as a benefit against this cost. The remaining yearly cost to the city of $38,000 is also entered as a benefit, since, if the city is to regard the tunnel as desirable, the costs of the tunnel, both annual charges and operation and maintenance, should be recovered from the rents paid by the participating utilities.

Under the subheading of taxes, an annual cost of $26,000 reflects the loss to the city of revenue from its franchise tax of 4% on utility property, if the utilities in a tunnel spend $640,000 less in capital investment. On the benefit side is $m_4$, representing a measurable additional real estate tax revenue to the city, because the assessed value of the buildings in the area would probably be greater because of the presence of the tunnel and associated conveniences. It has been assumed that $m_4$ would roughly balance the loss in utility franchise tax revenue.

Item 7a. The New York State government, under urban renewal procedures, would pay $788,000 toward the tunnel, which is shown in parentheses in annual form.

Item 7b. The federal government, through an urban renewal grant, would pay the bulk of the cost of the tunnel or $2,803,000. On an annual basis, this represents $179,000.

The federal government would also lose approximately $13,000 in income taxes that would be paid by the private utilities on their additional investment in conventional burial.

Item 9. Private utilities. The cost columns for each of the four participating utilities show the two capital costs for the alternative means of installation, and the rent that would be paid to the city for use of the utility tunnel. The benefit columns show first the savings in annual charges due to the lower capital investment, and second, estimates of maintenance savings possible in the tunnel. These estimates, which were arrived at in part through consideration of total maintenance expenditures for each utility, approximate the savings that could be expected in this area.

a. Electric. Associated with the $20,000 difference in capital investment between conventional burial and the tunnel system would be savings in annual charges — return on investment, taxes, depreciation, etc. — of approximately $3,000. Yearly maintenance savings of $1,000 were estimated from data on cable and joint failures.* This assumes that failures due to such causes as mechanical damage and corrosion would be decreased in the tunnel system, and that the costs of repair per failure would be less with easier access and no traffic control problems.

b. Gas. Annual savings of $13,000 result from the difference in capital investment between the two systems. Maintenance savings, $m_5$, are measurable, but in the absence of any statistics about the probability of leaks were not estimated. There is a possibility that short-term maintenance costs might be greater since every leak would be detected in the tunnel by the sensing system and would have to be fixed, but there would probably be a long-term gain since

*"Cable Operation, 1964" Edison Electric Institute, New York, N.Y., 1964, 29 pp.

replacement could be on a scheduled basis.

c. Telephone. The telephone system would also show savings in annual charges due to decreased capital investment. The savings in maintenance were estimated by assuming that the same factors would apply as in the case of electric cables.

d. Heating and Cooling. Maintenance savings of $5,000 for this system were estimated by comparing the maintenance cost of a conventionally buried central heating-cooling systems with those for a similar system in a tunnel. Since the systems were roughly comparable in terms of age of system and load, it was assumed that 80% of the difference in maintenance costs were due to the protection afforded by the tunnel.

For each of the private utilities, as well as for the city-owned utilities, a $r_i$ has been entered in the table as an annual cost. These $r_i$ are the rents paid to the city for use of the tunnel space. Note that they must at least equal $57,000, the sum of the tunnel's operating and maintenance expense and the annual repayment costs for the city's bonds, if the tunnel is to be judged economically feasible from the city's point of view. Since the sum of the annual savings to the private utilities and the city departments $101,000 + $m_1$ + $m_2$ + $m_3$ + $m_5$, is greater than $57,000, it would appear that the city could definitely recover its costs.

### 5.3.2 Consumers

Item 4. City users. A benefit to motorists, $m_6$, is listed to signify that measurable benefits in terms of time saved, reduced accident frequency, gasoline savings, etc., would accrue because of less frequent traffic obstructions. For pedestrians, $i_1$ signifies the intangible advantage of sidewalks and streets unimpeded by utility repair crews and associated traffic congestion.

Since room for future expansion for all utilities is available in the tunnel, $i_2$ is listed as a benefit for utilities. This benefit must be considered intangible in the time scheme of this study since

none of the utilities included was willing to predict any necessity for major expansion of their lines within 20 years. Although it is true that for an urban renewal project area, prediction is easier than for the average city block, utility companies have underestimated growth before, and may well again.

Item 6. City as a whole; new site occupiers. The table lists two intangible benefits, $i_3$ and $i_4$, which refer to the esthetic advantages of a park-like setting that is not disturbed by utility maintenance and repairs, and to the possible benefits for stores in an area unhampered by street cuts and ensuing traffic jams. To a certain degree, these benefits would be measurable, $m_7$, as the increased value of real estate in the area, which would accrue to the owners of the real estate in the form of increased rents, and, as mentioned above, to the city as increased tax revenue. The whole city of White Plains would benefit from such advantages to the intangible extent that business, hotels, conventions, etc., were attracted to the area.

Another intangible benefit that would accrue along with the improved access and maintenance of utility lines, is the reduced probability of gas leakage and explosion, $i_5$, however, a physical cost, $p_1$, was included to represent the remote chance of a major gas leak resulting in a major explosion.

Item 8. Nation as a whole. The nation would benefit to the extent that information about the value of utility tunnels in themselves and as possible dual-use shelter systems were produced by this project.

Item 10. Utility consumers. The measurable excess of savings afforded the utility companies by the tunnel over rent paid for use of the tunnel should, by law, be passed on to consumers.

The relevant point of view for this analysis and for the decision about a utility tunnel in White Plains is that of the city of White Plains. If the Federal and State grants are considered merely as inputs, the tunnel would compare attractively with conventional utility systems in the central renewal area. As discussed above, the

savings of the participating utilities in capital and maintenance charges would enable them to pay rental charges that would pay off the city's investment, and cover the operating and maintenance costs of the tunnel. The utilities would in addition gain the advantages of sheltered work space, free access, protected environment, etc., that many of them cite favorably but are unwilling to assign monetary value.

However, this study has not considered possible alternate uses of funds, nor would it be easy to determine an internal rate of return for a tunnel to compare it with other possible projects. To cite only the most obvious fact, the projected cost of the total urban renewal project has increased over 300% in the 10 years since it was first proposed. This and the many other crying needs for most cities today--schools, housing, transportation* -- may well be considered more urgent than utility tunnels.

It should also be noted that the "savings" due to reductions in annual charges for the private utilities involve redistribution of assets and the income therefrom rather than "real" savings. In a tunnel, the utilities would operate equivalent facilities with a lower total investment. Because of the lower investment, payments to governments in the form of taxes and to bondholders in the form of interest would be less. Thus the apparent savings, which could be used to pay rent. The only real as opposed to redistribution savings appear to be savings in utility operation and maintenance expense and savings in traffic costs.

### 5.3.3 Possible Institutional Constraints

To round out the study some legal, institutional, and sociological problems that might accompany municipal ownership of a tunnel constructed with urban renewal funds where space is rented to several different

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*see, e.g., State and Local Public Facility Needs and Financing, Joint Economic Committee, U.S. Congress, Washington: U.S. Government Printing Office, 1966.

utilities have been considered.

1. New York state laws governing municipal ownership of utilities. According the state laws, the City of White Plains could legally own and operate such a tunnel. If constructed by the local Urban Renewal Agency, a tunnel could be deeded to the city as a utility easement, and it could be maintained and operated by a city department. Under its charter and the state statutes, the city could issue either revenue or general obligation bonds to pay for a tunnel if it so chose and the city voters approved.

2. Federal Urban Renewal Regulations. No precedent exists since no utility tunnel as such has yet been built with urban renewal funds. The most likely interpretation of existing statutes would be:

a. The tunnel would be a "publicly owned utility facility" and thus an "eligible project improvement." (Urban Renewal Manual, 11-1-1). Eligible project improvements may be charged to Gross Project Cost, or if paid for by the city, offered as a non-cash local grant-in-aid.

b. The Local Project Agency may dedicate the land or easement in land required for a project improvement, as well as the improvements themselves, to the public entity that will be responsible for its operation and maintenance. (Urban Renewal Manual 14-3-3)

c. However, any land or easement for a public improvement that is in excess of requirements for the project itself shall be sold at not less than fair value. (Value for the most suitable alternative private use for the land.) This last qualification may be significant in White Plains because both the local Consolidated Edison substation and the New York Telephone building are located in the urban renewal area and large electric transmission and telephone feeder lines that do not serve the immediate area would be installed in the tunnel. However, the fair value for this underground space may be low or non-existent.

3. City-utility relations. Private utilities, especially electric and gas, have different viewpoints compared with public utilities and authorities, and may resist the changes necessary to install a city-owned utility tunnel. The possibilities of resistance

may be enhanced by a tunnel with many different utilities using the same space and with monitoring and inspection by the tunnel operator. Similar situations are found in three cities, Baltimore, Montreal, and New Britain, Conn., in which the city owns underground conduit and rents space to various utilities for power and communications lines. The main continuing problems found in these cities are as follows:

a. "Free space". In Baltimore, the city has claimed that as landlord it is entitled to use the conduits for its system without charge. This means that the private utilities, through their rental payments, have paid most of the systems' operating budget, even though the city's lines use 1/5 of the occupied space.

The utilities' position has been that they would not be in the city system if the city were only a landlord-- that the city requires them to use the system through legislation and thus the city should pay its share. Last year the Baltimore city council adopted the utilities' position, but discussion continues as to whether this decision should apply retroactively.

b. Liability. In these city owned systems, damage to the lines of a utility is paid for by the damage-causing agent, be it city or utility. However, if damage were to be caused by a bankrupt utility, as was the case in Baltimore when soon-to-be-discontinued transit company cables were poorly maintained, there is no way to gain redress. Moreover, in these systems, liability for damage to their system by non-negligent failures has been assumed by the participating utilities, and the probability of such non-negligent damage occurring might be increased by a larger number of separate utilities occupying a tunnel.

c. Inspection. In general, utility companies did not favor the requirement of a city inspector when work is done in the system, however, inspection and limited access would probably be necessary.

## 5.4 DUAL-USE OF THE WHITE PLAINS TUNNELS AS BLAST SHELTERS

Use of the proposed utility tunnels as civil defense shelters would require a number of modifications and additions to the tunnel

system. These include: entrances, blast doors, air conditioning systems, life support systems, storage for food and medical supplies, and sanitary facilities. The cost of these items can be broken down into time dependent and time independent costs. Time dependent costs are those which should be incurred at the time original construction is initiated, and time independent costs are those that can be deferred until such time as the conversion to shelter may be necessary. In the case of the utility tunnel, it was assumed that all additional excavation and construction for storage rooms, sanitary facilities, air conditioning equipment, and entrances were time dependent so that the city streets were not torn up at a later date. The equipment for these areas could be deferred.

It was estimated that the maximum daylight population in the Central Renewal Project would be about 20,000 people. Because the exact use of space in the Westchester Forum is not known at present, no accurate estimate of nighttime population is known but it is probably less than 5,000. In calculating costs for civil defense, design populations from 5,000 to 20,000 people were used. Space and floor area available for each shelter occupant in the White Plains tunnels are given in Table III for shelter populations from 5,000 to 20,000. At higher population densities the floor area per person is considerably less than normally specified. However, even though the floor area would be small, because of the connections to building basements and parking garages it would be possible to relieve crowded conditions after an attack and prior to return to the surface by moving part of the shelter occupants to these areas.

Table III. Unit Areas and Volumes Available in the White Plains Tunnels

| | Shelter Population | | | |
|---|---|---|---|---|
| | 5,000 | 10,000 | 15,000 | 20,000 |
| Unit Volume ($ft^3$/person) | 180 | 90 | 60 | 45 |
| Unit Area ($ft^2$/person) | 14 | 7 | 4.[illegible] | 3.[illegible] |

### 5.[illegible].1 Environmental Control System

Ventilation and Air Conditioning

Emergency conditions for White Plains were assumed to require air conditioning equipment that would operate in a "button-up" condition for up to eight hours and for a continuous period of 30 days following the "button-up" period.

Air conditioning requirements for the long period of occupancy (after an initial period of two hours) were first considered. It was assumed that 5[illegible] Btuh is given off by each person ([illegible] Btuh sensible heat and 200 Btuh latent) and the dry bulb temperature within the tunnel would be maintained at [illegible]°F with a wet bulb temperature of 71°F. The effective temperature would therefore be [illegible]°F. Other sources of heat considered were lights, $CO_2$ removal, [illegible] cfm per person of outside air, and heat losses from mechanical equipment. If a temperature rise in the tunnel air of 2[illegible]°F were permitted, the quantity of conditioned air required would be [illegible] cfm per 1,[illegible] people. The conditioned air to the tunned was assumed to have a dry bulb temperature of 5[illegible]F and a wet bulb of [illegible]°F. Approximately 72 tons of air conditioning would be required per 1,[illegible] people.

During the initial period, when the people are nervous and excited, their metabolism rate would be increased. This would cause the heat produced by the sheltered population to be somewhat higher, possibly reaching 1,[illegible] Btuh at the very beginning ([illegible] Btuh sensible and 7[illegible] Btuh latent heat). The temperature of the concrete tunnel was assumed to be an average of the ground and outside air temperature or approximately 7[illegible]°F. The temperature of the concrete service modules was assumed to be that of the surrounding soil, approximately 5[illegible]°F in White Plains. As the air circulated through the tunnel picks up heat from people and other sources, there would be a temperature differential between the air and the face of the concrete. Some heat would be transferred from the air to the concrete of the tunnel and service modules, while some would be removed by the extra capacity that the cooling coil would have when no outside air was being supplied or

lithium hydroxide being used. The concrete, together with the extra coil capacity should absorb the heat generated in the tunnel during the initial period and keep the temperature inside the tunnel within acceptable limits without requiring additional refrigeration capacity during the button-up period beyond that required for long time occupancy.

Since the exterior air might be highly contaminated with carbon monoxide and the other toxics from the burning of structures and debris after an attack it might be necessary to operate the shelter ventilation system in the buttoned-up condition for the duration stated previously. It is assumed, however, that sampling devices would periodically test the air content at various inlet air locations, and that outside air would be taken in if the air were uncontaminated.

Calculations showed that heating would probably not be needed in the tunnel during an emergency even if it occurred during the coldest months. This conclusion was reached when it was found that cooling would still be required after supplying outside air at [illegible]°F to the tunnel.

Oxygen Supply and Carbon Dioxide Removal

Values for the human consumption of oxygen and the production of carbon dioxide were taken from "Environmental Engineering for Fallout Shelters."[illegible] These values were: [illegible] cubic feet of oxygen/hour/person and [illegible] cubic feet of carbon dioxide/hour/person. This reference also included tolerance limits for these gases.[3] Values quoted were: 1[illegible] percent for minimum oxygen, and 1 percent for maximum carbon dioxide. However, it was also reported that [illegible] percent carbon dioxide could be tolerated for 2[illegible]-hour exposure, and [illegible] percent could be considered the maximum for 1-hour exposure.[illegible] In this study both the 1 percent carbon dioxide level and the [illegible] percent limit have been considered. For an [illegible]-hour button-up period and a shelter population of [illegible], some form of carbon dioxide removal system would be required. Only at a shelter population of [illegible] people could an [illegible]-hour period be provided without greatly exceeding the [illegible] percent limit. If no carbon dioxide removal were provided, the button-up

period to reach 3 percent carbon dioxide would range from 1.6 hours to [illegible] hours for shelter populations of 20,000 and 5,000 respectively.

Different schemes for extracting carbon dioxide during the button-up period have been suggested.[5] The one selected utilizes lithium hydroxide canisters placed in a bank similar to a filter bank located in the air stream in the equipment room of the system. Carbon dioxide sampling instrumentation would be located in the return duct system which would control dampers that would let the return air flow through the canisters for extraction of the carbon dioxide. The chemical process involved in this extraction is exothermic with approximately 100 Btu being liberated with the absorption of each cubic foot of carbon dioxide.

Although a minimum oxygen concentration of 16 percent was used in this study, it has been reported that concentrations as low as 1[illegible] percent could be tolerated for short intervals.[6] For a shelter population of 20,000 the allowable oxygen concentration of 16 percent would be reached in 1.1 hours.

Two methods were considered for supplementing the air with oxygen during the button-up period; sodium chlorate candles and bottled oxygen. Bottled oxygen was chosen because it appeared to be the most economical. Banks of oxygen cylinders would be stored in the return air plenum valved for automatic controlled feed into the air supply. The valves would be regulated by oxygen sampling instrumentation in the return air plenum.

After the button-up period (during the next 30 days) 60,000 cfm of outside air would be supplied to each system to meet the oxygen and carbon dioxide concentration requirements. With 3 cfm per person of outside air as makeup there would be an adequate factor of safety for carbon dioxide removal and oxygen supply. Also, the 3 cfm per person of makeup air would help control the problem of odor.

## 5.4.2 Details of System

Different types of systems were considered for conditioning the air for the tunnel. Because of the presence of the central heating and cooling plant and the existing chilled water lines in the tunnels, use of this system appeared to offer economic advantages. By hardening a portion of the central plant cooling capacity at the time of construction, this facility could be used as a chilled water supply for the shelter.

### Module Equipment

Twenty separate air handling modules appeared to be the most feasible way of providing the shelter requirements. These modules would be installed adjacent to the tunnel at about 350 ft intervals. Each module would meet the needs of approximately 1,000 people and would have a cooling capacity of 65 tons. Each module would consist of the following components:

a. Outside air intake - this would be provided with a blast valve and would be "hardened" to withstand blast. The same intakes and exhausts would be used for the shelter environmental control system as those used for normal operation of the utility tunnel.

b. Lithium hydroxide canisters - each canister is 10 inches long and 8 inches in diameter. Each contains 6.4 lb. of granular anhydrous lithium hydroxide. One hundred canisters would be required per system. The canister bank would have dampers on the inward flow side to let the air flow through when extraction of $CO_2$ was needed. Also, dampers would be installed so that the air flow could be directed around the bank of canisters.

c. Oxygen Cylinders - Twenty-six oxygen cylinders of standard 244 cubic feet size would be needed per system.

d. Prefilters - provided to filter out the larger of the particulates which could be in the return and makeup air as well as any lithium hydroxide attrition.

e. Charcoal filters - used to reduce the odor problem.

f. HEPA filters - to remove small particles carrying radioactive fallout that would be brought in with the outside air makeup. They would also filter out any charcoal filter attrition.

g. Fan - double width, double inlet fan that would supply and return the air to the tunnel.

h. Ductwork - extends down the top of the tunnel in both directions (approximately 150 feet in each direction) from the equipment room so that some degree of temperature control could be maintained.

i. Plenum - a plenum located at the side of the equipment room which houses the air conditioning equipment would provide a return air path for this system, an equipment access, and a place for storage of oxygen cylinders.

j. Chilled water coils - coils in each module would be sized to provide 72 tons of cooling capacity. Approximately 144 gpm of chilled water would be required for each module. Existing chilled water lines installed in the tunnel would be used to supply the modules.

Central Plant

The proposed central cooling plant for the White Plains Central Renewal Area would contain ten 2,200-ton chillers, two 150-million Btu/hr. boilers, and an 800-kw emergency generator. Two of the proposed chillers would be "hardened" underground so that a standby unit would be available to operate the environmental control systems in the tunnel during an emergency. The chillers would be required to furnish approximately 1,440 tons of refrigeration, and would supply chilled water at 40°F.

Approximately 800 gpm of makeup water would be supplied to the existing cooling towers at the central plant by a drilled well. If all cooling towers were destroyed, this makeup water could be supplied directly to the condensers of the hardened chillers.

### 5.4.3 Water Storage

White Plains obtains its water supply from the New York City aqueduct system. The availability of this water supply after attack was not known and a water storage system has been provided for shelter use. Use of the well at the central cooling plant as a source of potable water was not considered because of a lack of data on groundwater quality in the area. Table IV gives the assumptions used in calculating water storage requirements.

Table IV. Water Storage Requirements

| Use | Gallon/Person/Day |
|---|---|
| Drinking and Food Preparation | 0.5 |
| Sanitation | 1.5 |

Potable water mains would exist in the utility tunnel. If these lines were intact and could be valved off, 6.6 day's supply (68,000 gal.) would be available for domestic use. In the shelter design this capacity was assumed to be available in addition to the water stored for shelter use. In the case of sanitation water, storage for a one day's supply was provided. The remainder of the water for this purpose would be supplied by the well at the heating and cooling plant. A flow of 2.1 gpm would be sufficient to supply all sanitation water needs.

### 5.4.4 Sanitary Facilities

As described in the previous section on water storage, it was assumed that minimum water would be available for sanitary purposes. For this reason chemical toilets were provided. Waste from the chemical toilets and sinks would be pumped to the existing sewer system by a pneumatic ejector. Minimum design requirements for the sanitary facilities were one water closet for each 40 men, one water

closet for each 30 women, one urinal space for each 40 men, and one wash basin for each 60 people. In addition, large sinks were provided in each module for washing of miscellaneous items.

A modular system was used, providing facilities for 1,000 men and 1,000 women per module. The chemical toilets and urinals have common tanks which would be connected to the sludge ejector. Ventilation air (2 cfm/seat opening) would be drawn into the tank and exhausted to the outside. Each module would contain 26 water closets for men, 40 water closets for women, 4 urinal troughs for men, 36 wash basins, and 90 cubic feet of storage area for sanitary supplies and chemicals. Also each module would include a 3,000-gallon water tank for sanitary purposes (one day supply for 2,000 people), and a 30,000-gallon drinking water storage tank (30 days supply for 2,000 people).

### 5.4.5 Food Storage

Storage space for standard OCD food packages (based on one food package for five people for five days) would be provided. For a reference population of 20,000 people for 30 days this amounts to a needed storage volume of 36,500 $ft.^3$ For modules of 5,000 people, this would be a space 10 ft. high by 10 ft. wide by 100 ft. long including space for access.

### 5.4.6 First Aid and Medical Supplies

Storage volume for first aid supplies were based on the use of OCD Medical Kit C, which would supply the needs of about 300 people for 14 days. The volume of each kit is 5.2 $ft^3$. For a shelter population of 20,000, a storage volume of 750 $ft^3$ would be required. Modules for 5,000 people would be so small that they could be included in the space requirements for food storage. In this study this was done.

The maximum tunnel population was not sufficient to justify a packaged disaster hospital, and it was not considered necessary to

itemize the space requirements for less than one complete packaged unit. Hospital space was estimated to be 1,500 $ft^3$ for a shelter population of 20,000.

5.4.7 Miscellaneous Space

Space would also be required for limited food preparation areas, office space for shelter managers, and miscellaneous supplies as tools, spare parts, fire fighting equipment, etc. It was estimated that 2,500 $ft^3$ of space should meet the needs of 20,000 people.

5.4.8 Emergency Electrical System

Diesel emergency generators would be provided having a combined capacity of 3300 kw. They would be located in hardened underground structures near the central cooling plant. The existing lighting system in the utility tunnel would be used for shelter lighting.

5.4.9 Shelter Entrances

There would be 16 spur connections from the main tunnel to building basements or underground parking garages which would normally be used for utility connections and maintenance access. The spur tunnels would be 8-feet in diameter and would be equipped with 4-feet wide blast doors for use as shelter access facilities. Use of these tunnels would allow people to enter the tunnel from the building basements and parking garages without going out onto the streets. Also, these tunnels would allow the use of space in the basements or parking garages for storage of emergency supplies.

It also would appear desirable to have at least two outside entrances to the tunnel for people who are not inside the buildings. These entrances would be located near tunnel intersections and would be equipped with 8-foot wide blast doors.

This number of entrances would be sufficient to allow about 20,000 people to enter the shelter in 15 minutes.[7] For shelter

populations much less than 15,000 people,no outside entrances would be required, however, it might be desirable to provide one or two. It was assumed that the 16 existing entrances to the tunnel would require blast doors for all cases.

### 5.4.10 Blast Protection

The utility tunnels as designed for White Plains have an inherent blast resistance of about 60 psi with proper design of the reinforcing steel and the addition of small amounts of reinforcing steel. Addition of small amounts of reinforced concrete to the roof slab could be used to increase the blast resistance to 100 psi, if desired.[1] For this study the 60 psi blast value was used.

### 5.4.11 Cost of Shelter Conversion

Support facilities required for shelter use were designed on a modular basis. Modules for sanitary facilities and water storage were based on 2,000 occupants, environmental control units for 1,000 occupants, and storage areas for units of 5,000 people. In estimating costs for generators and water chillers, it was assumed that the cost was proportional to required capacity. It was further assumed that the water chillers in the central plant would be hardened for use as the supply of chilled water and that the units installed would be such size as to meet the desired shelter population. The only cost included for the chilled water supply was the cost associated with hardening the required units, since the utility tunnel would already contain the distribution lines.

All existing entrances into parking garages and building basements would be provided with blast doors and would be available for shelter use. However, for shelter populations of 15,000 and over additional outside entrances were provided (see Section on Shelter Entrances).

Costs were estimated for two cases: button-up times of 6 hours, and button-up times limited by the accumulation of carbon dioxide

from the shelter occupants. Carbon dioxide was selected because of the high cost of removal and the short time to attain the maximum allowable concentration. Inherent button-up times with no provision for carbon dioxide removal vary from 8 hours for a population of 5,000 people to 2 hours for a 20,000 person shelter.

Both time-dependent and time-independent costs were estimated for design populations from 5,000 to 20,000. The costs associated with converting the White Plains utility tunnels to dual-purpose blast shelters are given in Table V for the two assumed cases. Noteworthy was the fact that about 60 percent of the conversion cost was time-independent at all shelter populations when carbon dioxide removal was required. In cases where carbon dioxide removal was not required the deferable costs were about 50 percent of the total.

The environmental control system and the electric system represented the largest deferable costs because the equipment required for these systems cost much more than the space required to house it. In the case of entrances, storage, and sanitary facilities the cost of supplying space was much more than the cost of equipment.

It should be noted that the costs reported in Table V do not include the deferable costs associated with stocking the shelter. Such items as food and medical supplies, chemicals for the sanitary facilities, and hammocks and other survival gear were not cost estimated.

Table VI shows tunnel and shelter costs on a dollars per person basis. It can be seen that the unit cost of shelter conversion was relatively insensitive to shelter population; however, the tunnel cost on a unit cost basis decreased with increasing population.

## 5.5 ALTERNATIVE TUNNEL DESIGNS

Studies have been initiated on alternative tunnel shapes and materials of construction. Most of the tunnels studied for White Plains were rectangular in cross section because it appeared that space utilization was better for rectangular shapes than for circular

Table V. Summary of Civil Defense Shelter Costs
(Thousands of Dollars)

| Item | With Carbon Dioxide Removal Capability | | | | Without Carbon Dioxide Removal Capability | | | |
|---|---|---|---|---|---|---|---|---|
| | 5,000 | 10,000 | 15,000 | 20,000 | 5,000 | 10,000 | 15,000 | 20,000 |
| Entrances | | | | | | | | |
| Time Dependent Cost | 180 | 180 | 251 | 330 | 180 | 180 | 251 | 330 |
| Time Independent Cost | 240 | 240 | 260 | 278 | 240 | 240 | 260 | 278 |
| Storage Space | | | | | | | | |
| Time Dependent Cost | 40 | 80 | 120 | 160 | 40 | 80 | 120 | 160 |
| Time Independent Cost | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Sanitary Facilities and Water Storage | | | | | | | | |
| Time Dependent Cost | 300 | 600 | 800 | 1,200 | 300 | 600 | 900 | 1,200 |
| Time Independent Cost | 90 | 134 | 276 | 367 | 90 | 134 | 276 | 367 |
| Environmental Control | | | | | | | | |
| Time Dependent Cost | 79 | 158 | 237 | 316 | 79 | 158 | 237 | 316 |
| Time Independent Cost | 190 | 746 | 1,119 | 1,492 | 180 | 361 | 540 | 721 |
| Electric System | | | | | | | | |
| Time Dependent Cost | 107 | 215 | 322 | 429 | 107 | 215 | 322 | 429 |
| Time Independent Cost | 303 | 606 | 908 | 1,211 | 303 | 606 | 908 | 1,211 |
| Sub-Total Costs | | | | | | | | |
| Time Dependent Cost | 706 | 1,233 | 1,830 | 2,435 | 706 | 1,233 | 1,830 | 2,435 |
| Time Independent Cost | 817 | 1,777 | 2,563 | 3,348 | 817 | 1,393 | 1,984 | 2,577 |
| GRAND TOTAL COST | 1,523 | 3,011 | 4,393 | 5,783 | 1,523 | 2,626 | 3,814 | 5,012 |
| Allowable Button-Up Time (hours) | 8 | 8 | 8 | 8 | 8 | 4 | 3 | 2 |

Table VI. Shelter Cost in Dollars Per Person

| Item | With Carbon Dioxide Removal Capability[a] | | | | Without Carbon Dioxide Removal Capability[b] | | | |
|---|---|---|---|---|---|---|---|---|
| | 5,000 | 10,000 | 15,000 | 20,000 | 5,000 | 10,000 | 15,000 | 20,000 |
| Civil Defense Costs | | | | | | | | |
| Time-Dependent | (c) | 120 | 120 | 120 | 140 | 120 | 120 | 120 |
| Time-Independent | (c) | 180 | 170 | 170 | 170 | 130 | 130 | 130 |
| Sub-Total Civil Defense | (c) | 300 | 290 | 290 | 310 | 260 | 250 | 250 |

(a) Button-Up Time 8 Hours for all populations.

(b) Maximum Button-Up Time 8 hours for 5,000; 4 hours for 10,000; 3 hours for 15,000; and 2 hours for 20,000.

(c) Carbon Dioxide removal not required.

cross sections. Circular sections provide greater blast resistance for the same wall thickness and present a possible advantage in that they are available as precast or premade units.

Precast concrete sewer pipe has been proposed as a possible construction material for dual-purpose shelters.(8) With this type of pipe there would be a potential problem with water leakage at the joints. Speci[illegible] sealing rings are available to reduce this leakage. Another type of concrete pipe that could be used is steel cylinder embedded concrete pressure pipe. This pipe is used mainly for water transmission, and is designed so that joint leakage is negligible.

Prefabricated corrugated metal sections are also available in a number of sizes and wall thicknesses. Special coatings are available to eliminate corrosion on the outside of the pipe.

Costs and calculated blast resistance of representative sizes of these materials are shown in Table VII.

Table VII. Cost and Blast Resistance of Various Types of Circular Sections

| | [illegible]-in. Diameter | | [illegible]-in. Diameter | |
|---|---|---|---|---|
| Construction Material | Cost $/ft. | Blast Resistance psi | Cost $/ft. | Blast Resistance psi |
| Concrete Sewer Pipe | 70 | [illegible] | [illegible] | [illegible] |
| Concrete Pressure Pipe | 64 | [illegible] | [illegible] | [illegible] |
| Armco Multiplate (0.1[illegible]-in. Wall) | [illegible] | [illegible] | 56 | [illegible] |
| Armco Multiplate (0.276-in. Wall) | [illegible] | 75-100 | 107 | [illegible] |

The costs reported in Table VII are for the cost of the pipe only and do not include installation or trenching costs. It can be seen that greatest blast resistance is provided by the concrete pipe. The multiplate pipe is cheaper but its blast resistance is lower. A small

premium must be paid to insure truly waterproof joints by using the concrete pressure pipe. The cost of a rectangular concrete section to produce the same cross-sectional area as the 96-in. pipe would be about $75 per foot (7ft. by 7 ft.), and would have a blast resistance of less than 60 psi.

## 5.6 NEW UTILITY CONCEPTS FOR NEW CITIES

Installation of utility tunnels in new cities or urban renewal areas would provide a potential solution to a number of problems related to the use of city streets by heavy trucks, in addition to their use for conventional utilities or new utilities. These include:

1. Installation of pumped sewers instead of gravity flow sewers as are currently used.
2. Use of tunnels for movement of solid wastes. These could be moved through the tunnels by (1) compacting, packaging, and hauling through the tunnels by narrow gage railroads or rubber-tired vehicles; or (2) by grinding and pumping through special pipelines in the tunnels either pneumatically or as an aqueous slurry.
3. Use of the tunnels to transfer goods to and from businesses located within the area. Intracity goods could be unloaded at a central facility and routed through the tunnels on small rubber-tired vehicles or railways, and vice versa.
4. Use of the tunnels to transfer letter mail using pneumatic methods (tube mail). Such a system could be provided between a central post office and branch post offices, or perhaps to individual buildings.
5. Transportation of large volumes of hot water from a nuclear power plant to a central user and return. This water could be used as a source of central heating and cooling.

### 5.6.1 Pumped Sewer Systems

With slight changes in technology, additional present-day utilities could be included in utility tunnels. One of the utilities excluded

from the White Plains study was the sanitary sewer system. All of the sewers in the White Plains study area are gravity flow sewers and must continue to slope downward for their operation. Most of the existing sewers will remain, and design of the White Plains tunnel system to the required depths and grades for the few new lines was not considered warranted.

However, if a new city is considered, it might be possible to design a pumped sewer system to replace the conventional gravity flow system. As a basis for analyzing a new city system, a cost comparison was made of pumped versus gravity flow sewers for a hypothetical area of a new city using the layout of the White Plains Urban Renewal Area and flat surface topography as a basis. Sewage flows were calculated and conceptual designs of the gravity and pumped systems were prepared based on the design population of each building. The designs were based on the following assumptions:

1. The entire area is a level plane.
2. The frost line does not extend below 2 feet from the surface.
3. All buildings have basement floor grades 15 feet below the ground surface.
4. The discharge of the sanitary sewer system is at the center of Fisher Avenue and South Lexington Avenue.
5. The velocities in the gravity sewer system are not less than 3 feet per second and not greater than 5 feet per second.
6. All gravity sewers are non-pressure Transite sewer pipe with ring joint couplings. The pressurized system is Class 100 Transite pressure pipe with ring joint couplings.
7. All pumping stations are duplex pump installations with the pumps in dry pits and are commercially available units with alternators. Each pump is capable of handling the entire flow of the station, and self-cleaning strainers are used on all pumps.
8. The maximum head requirement for the pumps is 70 feet. The maximum electrical power for an individual pump is 15 hp.

Cost estimates were made on a gravity flow system, and pumped

sewers. Results of these estimates are shown in Table VIII.

Table VIII

Construction Costs of Sewers for the Hypothetical New City Area

| | |
|---|---|
| Gravity Flow | $650,000 |
| Pumped | 359,000 |

It can be seen that a saving of about 35% in construction costs can be obtained using pumped sewers over new direct burial-gravity flow systems. This saving is produced by using smaller pipe sizes in the pumped sewer system, and less excavation required because the pumped sewers do not require a continual slope for their operation. However, operating costs in the form of pumping energy are involved in pumped systems and are not in the gravity systems. Based on an estimate of the sewage flows and their variation with time, the electricity costs per year were calculated using a rate of $0.01/kwh. About $2,400 per year would be required for the pumped system. Maintenance costs were not estimated in detail, but it appears there would be no significant difference between the two systems.

With a pumped system a power failure, such as the northeast blackout, would require stand-by power generation of 100 kw at an installed cost of $25,000. This power would be readily available for a civil defense shelter system. A possible way of avoiding the need for stand-by electrical generators would be to provide an overflow for individual building collection tanks to a gravity flow storm sewer system, plus an alarm signaling its use. This would result in the temporary pollution of the storm drainage system until power was restored, or a portable generator was provided, but could probably be tolerated in an emergency.

Based on this preliminary analysis of a pumped sewer system, it appears to be quite feasible to consider using it in new cities. Individual sections of the city would contain pumping systems, each discharging to a common gravity flow system which would convey the sewage to the treatment plant.

### 5.6.2 Advanced Solid Waste Handling

Approximately 4.3 pounds of solid waste are currently produced in the United States per person per day.[9] Collection and disposal of this material currently costs $3.2 billion per year or about $16.50 per person per year.[10] Of this figure, it is estimated that 85% of the total cost of providing refuse service is in collection costs.[11] What effect slurry pumping instead of manual collection might have on this cost is not known, but studies are being initiated to determine the feasibility and economics of such a system.

With all the interest currently being directed at the solid waste problem, it is interesting to estimate what volumes and weights of solid waste will be produced in future years to the year 2000. The U.S. Public Health Service has estimated that the production of solid waste per person in the United States will continue to rise. Extending their data to the year 2000 indicates that individual production of solid wastes will rise to about 6.8 pounds/capita/day in 2000 (see Figure 1). Using these figures, the annual waste production and the accumulated waste (since 1965) can be estimated.

Data reported for municipal solid waste disposal in the San Francisco Bay area indicate that solid waste compaction to a density of 30 lbs/$ft^3$ is obtained in their sanitary landfill operations.[12] They further estimate that solid waste production between 1963 and 2000 will require a landfill area (based on two, ten-foot lifts) of 16,600 acres or about 25.9 square miles for the Bay Area alone. If we assume that all solid wastes produced in the United States were handled by sanitary landfill methods using techniques similar to those in the San Francisco Bay Area, the amount of land committed for solid waste disposal in 2000 would be 1062.5 square miles (see Table IX). At the reported cost of $1/$ft^3$ for sanitary landfill in Los Angeles,[13] this would be a total investment of about $570 x $10^9$.

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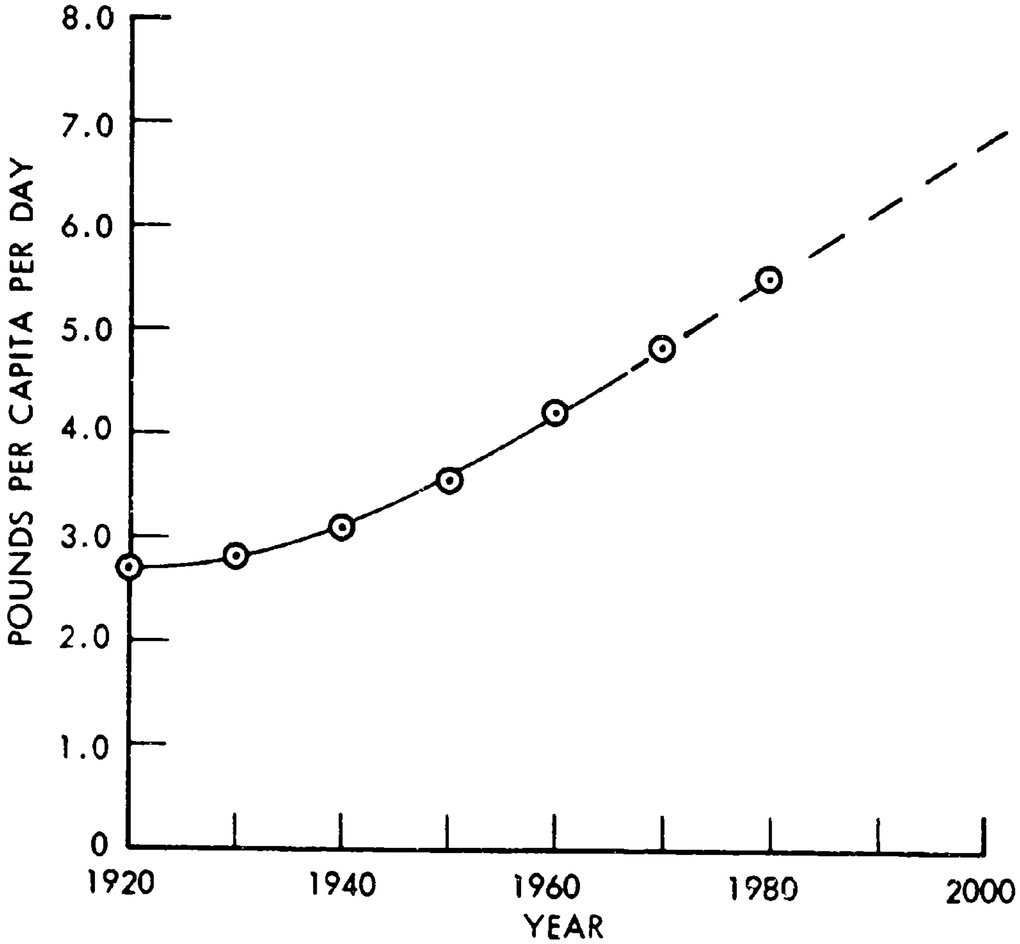


Fig. 5.1 Per Capita Production of Refuse in the United States

Table IX

Land Area Required if all Refuse Produced in the United States is Disposed of by Sanitary Landfill

| YEAR | ACCUMULATED SOLID WASTE ($10^9$ TONS) | SQUARE MILES OF LAND AT FINAL DEPTHS OF (1) | | |
|---|---|---|---|---|
| | | 10 FT | 15 FT | 20 FT |
| 1965 | 0 | 0 | 0 | 0 |
| 1970 | 0.85 | 187.5 | 140.6 | 93.8 |
| 1975 | 1.84 | 406.3 | 304.7 | 203.1 |
| 1980 | 2.99 | 671.9 | 515.6 | 343.8 |
| 1985 | 4.31 | 968.8 | 726.6 | 484.4 |
| 1990 | 5.82 | 1296.9 | 984.4 | 656.2 |
| 1995 | 7.55 | 1687.5 | 1265.6 | 843.8 |
| 2000 | 9.49 | 2125.0 | 1593.8 | 1062.5 |

(1) BASED ON FINAL COMPACTION TO DENSITY OF 32 LBS/FT$^3$.

Not only does this analysis show that large land areas would be committed for disposal operations, but it also can be used to indicate the number of vehicles required to collect the material and haul it to the final disposal area. In New York City in 1966 there were 2,700 private and 1,800 municipal refuse trucks in operation. For the entire United States it is estimated that there are 148,000 trucks operating. If the volume of solid waste continues to increase (about 3 times the 1965 production in 2000), then about 450,000 refuse trucks will be operating on city streets in the United States in the year 2000.

At the present time the use of individual garbage grinders in homes is quite common. These grinders released the garbage directly to the sanitary sewer system. Only in rare cases where the sewers are not large enough or the sewage flow is not sufficient to handle the additional solids added are the use of grinders excluded.[14] In Los Angeles, studies have been conducted to determine if garbage collected from individual homes can be transferred to central grinding stations and discharged to the sewers.[15]

However, garbage is only about 10% of the total solid waste generated.[16] (See Table X) Use of individual household units merely makes a small reduction in the volume of waste which must be collected. Sizes and capacities of existing sewer systems rule out their use for transporting the entire solid waste contribution. It might be possible, however, to provide a separate system to handle these wastes. This system could be either gravity flow or pumped. In this case, instead of handling the waste in the sewage treatment plant, the waste would be handled in a separate treatment plant.

A precedent does exist for grinding and slurry pumping non-segregated solid wastes. A large office building in Philadelphia, containing 1,000 people, generates about 4,000 pounds of waste material each day.[17] Once a day this material is pulped, metal and

Table X

An Average Composition of Municipal Refuse (% by Weight)

| | |
|---|---|
| RUBBISH (64 PER CENT) | |
| PAPER, ALL KINDS | 42 |
| WOOD AND BARK | 2.4 |
| GRASS | 4.0 |
| BRUSH | 1.5 |
| CUTTINGS, GREEN | 1.5 |
| LEAVES, DRY | 5.0 |
| LEATHER GOODS | 0.3 |
| RUBBER | 0.6 |
| PLASTICS | 0.7 |
| OILS, PAINT | 0.8 |
| LINOLEUM | 0.1 |
| RAGS | 0.6 |
| STREET REFUSE | 3.0 |
| DIRT, HOUSEHOLD | 1.0 |
| UNCLASSIFIED | 0.5 |
| FOOD WASTES (12 PER CENT) | |
| GARBAGE | 10.0 |
| FATS | 2.0 |
| NON COMBUSTIBLES (24 PER CENT) | |
| METALS | 8.0 |
| GLASS AND CERAMICS | 6.0 |
| ASHES | 10.0 |
| | 100.0 |

glass allowed to settle out, and the slurry pumped outside the building for later collection. As a result of the pulping operation the final volume of pulped waste is about 20% of the original bulk volume. The pulped waste is dewatered and handled by conventional methods.

The complexity of providing grinders and pumps for each individual household would probably rule out their use for this application; however, in high-rise apartment complexes and office buildings the method might prove feasible. Further work on waste characteristics from these sources, types of grinders required, and pumping characteristics of the slurry will be required.

One possible new disposal method for this slurried material would be the wet-air oxidation process. In this process at high temperature and pressure and with air bubbled through the slurry essentially 100% oxidation of the organic matter could be achieved. The resulting effluent, after gravity settling of inorganics (such as metals, glass, etc.) could be discharged into the sanitary sewer system or reused as the slurry pumping media. The settled material could then be packaged and handled by conventional means or by transport through utility tunnels. A possible flow sheet for this approach is shown in Figure 2.

Compacting and packaging of solid wastes at the source is also a potential solution followed by transfer in tunnels. At the end of the tunnel the packaged solid waste would be transferred directly to the disposal unit or to trucks for hauling to the disposal site. Specialized equipment for compacting and packaging is available,[18] but the economics of the total system are not known. However, this system would be more compatible with present-day practice than the slurry pumping approach.

### 9.6.3 Goods Movement

One of the major users of city streets are vehicles involved in delivering goods; either to stores, or from stores to purchasers.

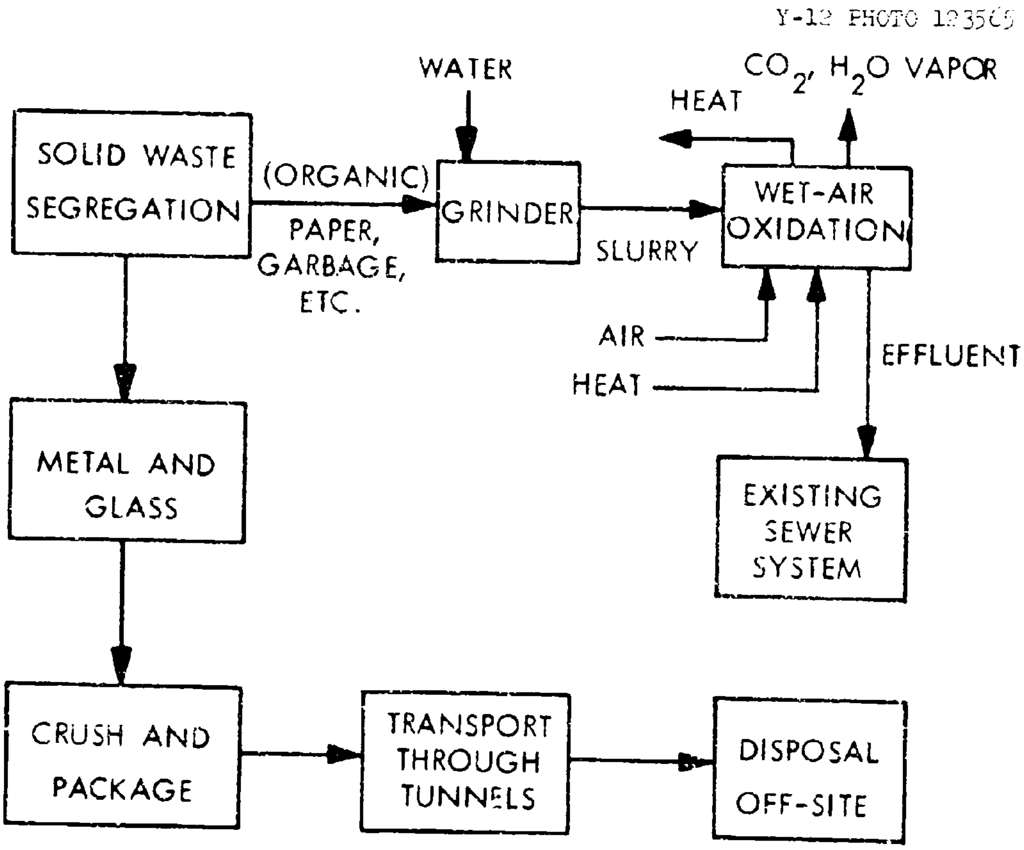


Fig. 5.2 Solid Waste Flow Sheet

In the future, small vehicles could operate in tunnels beneath the city streets for this purpose. It could be visualized that goods would be delivered to large warehouses on the perimeter of the city, where they would be sorted and assigned for delivery to specific stores. Vehicles in tunnels would then deliver directly from the warehouse to the store basements. For delivery from the stores the reverse could be true with truck delivery used only for the trip from the warehouse to the consumer.

### 5.6.4 Tube Mail

Use of pneumatic tubes for mail delivery has been used in Europe for many years. The system in Paris has been in operation since 1866.[19] Similar systems are reported in East and West Berlin, and London, England.[20] According to Reference 20, letters can be delivered within 90-minutes within the city, and within 3 hours in the suburban communities. An interesting feature of the Paris system is the use of sewers as the right-of-way. Thus the Paris sewers are used as a form of utility tunnel.

### 5.6.5 Transmission of Hot Water

Preliminary cost estimates for underground pipelines to convey large quantities of hot water from a nuclear reactor site to a user and the return of water at reduced temperatures ($200^{o}F$) from the user to the reactor have been made. Optimum velocities were calculated for 8 pipe sizes by minimizing the sum of the fixed capital charges plus the cost of pumping (capital cost of pumping stations was not included). Parametrically, supply temperatures from $250^{o}$ to $350^{o}F$ were investigated.

Conceptual design of the underground pipe arrangement has been patterned from a district heating system installed by Allegany Center, Inc. of Pittsburgh.[21] The basic difference is that steam was

used as the heat transfer medium instead of hot water.

Principal design and cost assumptions were:

1. 20 year amortization at 4 percent.
2. Pipeline operation 365 days per year.
3. Electricity costs 0.5¢ per KWH.
4. Pump and motor efficiency 70 percent.
5. Pipeline is new, clean, steel (no roughness factor).
6. Pipeline invert 6 feet below surface.
7. Cost estimates include an allowance for 35 percent indirect, 15 percent engineering, and 10 percent contingency.
8. Cost estimated for Oak Ridge area.
9. Nominal design pressure 300 psi.
10. Pipe sizes ranged from 4 to 36 in.

Results of the parametric study are shown in Table XI. The optimum velocity for all sizes is about 15 ft/sec. Pressure drops, amount of heat conveyed, and distribution cost for selected supply velocities of 5, 10, and 15 ft/sec for the 8 pipe sizes are given. The costs and pressure drops in Table XI are for one mile of system (one mile of supply and one mile of return), with a 325°F supply and a 200°F return.

The pipe lines considered do not operate at high pressure. If water is to be moved over long distances, either multiple pumping stations or higher design pressures would be required. What effect either of these factors would have on the cost of the system has not been assessed.

Table XI. Typical Characteristics of a One-Mile System

(at 325° F supply, 200° F return, one mile each way)

| Pipe Size (inches id) | Supply Velocity (ft/sec) 5: Head Loss (psi) | 5: Net Heat (Mw) | 5: Cost (¢/$10^6$ btu) | 10: Head Loss (psi) | 10: Net Heat (Mw) | 10: Cost (¢/$10^6$ btu) | 15: Head Loss (psi) | 15: Net Heat (Mw) | 15: Cost (¢/$10^6$ btu) |
|---|---|---|---|---|---|---|---|---|---|
| 4 | 89 | 3 | 22 | 313 | 7 | 13 | 657 | 10 | 11 |
| 8 | 40 | 13 | 8.8 | 140 | 26 | 5.1 | 295 | 40 | 4.4 |
| 12 | 25 | 30 | 5.6 | 88 | 59 | 3.2 | 185 | 89 | 2.8 |
| 16 | 19 | 48 | 4.7 | 66 | 96 | 2.6 | 140 | 145 | 2.2 |
| 20 | 14 | 77 | 3.6 | 50 | 154 | 2.0 | 107 | 230 | 1.7 |
| 24 | 11 | 112 | 2.9 | 41 | 224 | 1.7 | 86 | 336 | 1.4 |
| 30 | 9 | 174 | 2.4 | 32 | 349 | 1.4 | 67 | 523 | 1.1 |
| 36 | 7 | 254 | 2.1 | 25 | 508 | 1.2 | 54 | 762 | 1.0 |

## 5.7 REFERENCES


1. W. J. Boegly, Jr., W. L. Griffith, and K. P. Nelson, Civil Defense Research Project Annual Progress Report, March 1966 - March 1967, ORNL-4184, Part 1, pp. 242-267 (December 1967).

2. Office of Civil Defense, "Environmental Engineering for Fallout Shelters," TR-23, p. 174 (June 1964).

3. Ibid., p. 86.

4. S. H. Dole, "Environmental Requirements for Extended Occupancy of Manned Satellites," ASME Paper No. 59-AV-12 (March 1959).

5. See Reference 2, pages 311-318.

6. P. J. Rush, "Developments in Protective Shelter System," Technical Report R-357, U. S. Naval Civil Engineering Laboratory, Port Hueneme, California, p. 4-3 (April 1965).

7. National Bureau of Standards, "Design and Construction of Building Exits," U. S. Government Printing Office, Washington, D. C. p.40 (1935).

8. D. L. Narver, Jr., and D. T. Robbins, Engineering and Cost Considerations for Tunnel Grid Blast Shelter Concept, ORNL-TM-1183 (August 1965).

9. R. E. McKinney, "The Imminent Solid-Waste Crisis," The American City, p. 23 (June 1966).

10. "Staggering Growth Ahead," Refuse Removal Journal, p. 22 (January 1967).

11. W. E. Gilbertson and R. J. Black, "A National Solid Waste Program is Created," Compose Science (Autumn-Winter, 1966).

12. J. M. Kickey, "The Problem in Detail," Proceedings of a Conference on Solid Wastes Management, University of California, Davis Campus, p. 41 (April 4, 5, 1966).

13. Summary of Refuse Salvage and Reclamation Survey and Research Program on Residential Refuse Collected by the City of Los Angeles, Bureau of Sanitation, City of Los Angeles, p. 5 (April 1963).

14. Municipal Refuse Disposal, American Public Works Association, Chicago, Illinois, p. 234 (1966).

15. Planned Refuse Disposal, A Report to the Directors of the County Sanitation Districts, Los Angeles, California, pp. 81-83 (1955).

16. J. M. Bell, "Characteristics of Municipal Refuse," Proceedings of National Conference on Solid Waste Research, APWA, p. 37 (December 1963).

17. "Pulping System Reduces Waste to 20 Percent of Volume," Refuse Removal Journal, p. 6 and 32 (May 1966).

18. "Pack Refuse Into Paper Sacks With Automatic Units," Refuse Removal Journal, p. 18 (July 1966).

19. S. D. Grisquet, "Le Reseau de Transport Pneumatique a' Aigvillage Atuomatique," Chimie and Industrie, Vol. 32, SPNO (51-52) (October 1934).

20. Paul S. Jones, "Moving Things," Science and Technology, No. 74, pp. 18-30 (February 1968).

21. Lewis Smith, Heating Piping and Air Conditioning, pp. 118-122 (July 1965).

# 6. DALLAS DUAL USE TRUCK TUNNEL WITH PORTABLE COLUMNS

C. J. Williams and R. P. Kennedy*

## 6.1 INTRODUCTION

Last year's report on the potential dual use of a truck tunnel in Dallas, Texas,[1] determined the cost of providing blast protection ranging from 20 psi to 100 psi. The tunnel incremental costs were estimated using shelter occupancy ranging from 35,000 spaces to 70,000 spaces. It was found that the incremental cost of the overhead structural system was about 55% of the total incremental cost. The criteria used for the design of the structural components dictated that there be no major cracking of the structural system when they received the design loads. This was a conservative approach, for it is acceptable to have the overhead structural members crack, for civil defense purposes, as long as the shelter occupants are not injured.

For this report two new design criteria were used. The first allowed cracking of the overhead structural system. The yield line method[2] of structural analysis allows members to form cracks for the design loads. Taking advantage of this criteria, the overhead concrete slab thickness could be reduced. Second, the slab thickness was further reduced by designing for portable column placement at the center of the concrete slab. Smaller concrete beams and columns can be used to obtain the same ultimate strength when portable columns are available. By use of both criteria a reduction of incremental cost** was achieved.

This portable column concept was mentioned in a report[3] where it was stated that a fourfold increase of basement ceiling strength is achieved by adding new columns halfway between existing basement columns. Our results show that strengths are increased by a factor of two using yield line analysis.

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**Incremental cost is the additional cost of a structure with both a regular and an emergency use compared with regular use only. It is a function of, among others, the level of protection afforded in an emergency and in this report, the blast overpressure for which occupants are not injured.

## 6.2 CALCULATIONS

The approach used to design the two way slab, with a portable column at its center, was to evaluate the slab's resistance by an energy conservation method using yield line analysis. Figure 1 shows the yield pattern used. The effective depth of the slab is found to be

$$d = \left[\frac{M_{BS}}{0.0108\ f_{d\gamma}\ \phi_{BS}}\right]^{\frac{1}{2}}$$

where subscript BS = Bottom steel of the short span

$M$ = Moment $\left(\frac{\text{FT-KIPS}}{\text{FT}}\right)$

$\phi$ = Percent of steel

$f_{d\gamma}$ = Tensile steel dynamic yield stress (KSI)

The value of $M_{BS}$ is calculated from

$$M_{BS} = \frac{A}{C}\left[\sqrt{\frac{B + 2C}{C}} - \sqrt{\frac{B}{C}}\right]^2$$

where

$$A = \frac{wa^2}{12}$$

$$B = (1 + i_s) + \mu\alpha^2(1 + i_L)$$

$$C = (1 + j_s) + \mu\alpha^2(1 + j_L)$$

with

$$i_L = \frac{\phi_{TL}}{\phi_{BL}} \qquad i_s = \frac{\phi_{TS}}{\phi_{BS}}$$

$$j_s = \frac{\phi_{TCS}}{\phi_{BS}} \qquad j_L = \frac{\phi_{TCL}}{\phi_{BL}}$$

$$\mu = \frac{\phi_{BL}}{\phi_{BS}} \qquad \alpha = \frac{a}{b}$$

and w is the uniform load per unit area on the slab. The ratio $\alpha$ is the ratio of the short span to the long span. Calculations were made to determine the location of the rectangular crack pattern outside of the center portable column. Evaluation of problems associated with shear were determined at all critical points.[4] Figure 1 shows vertical

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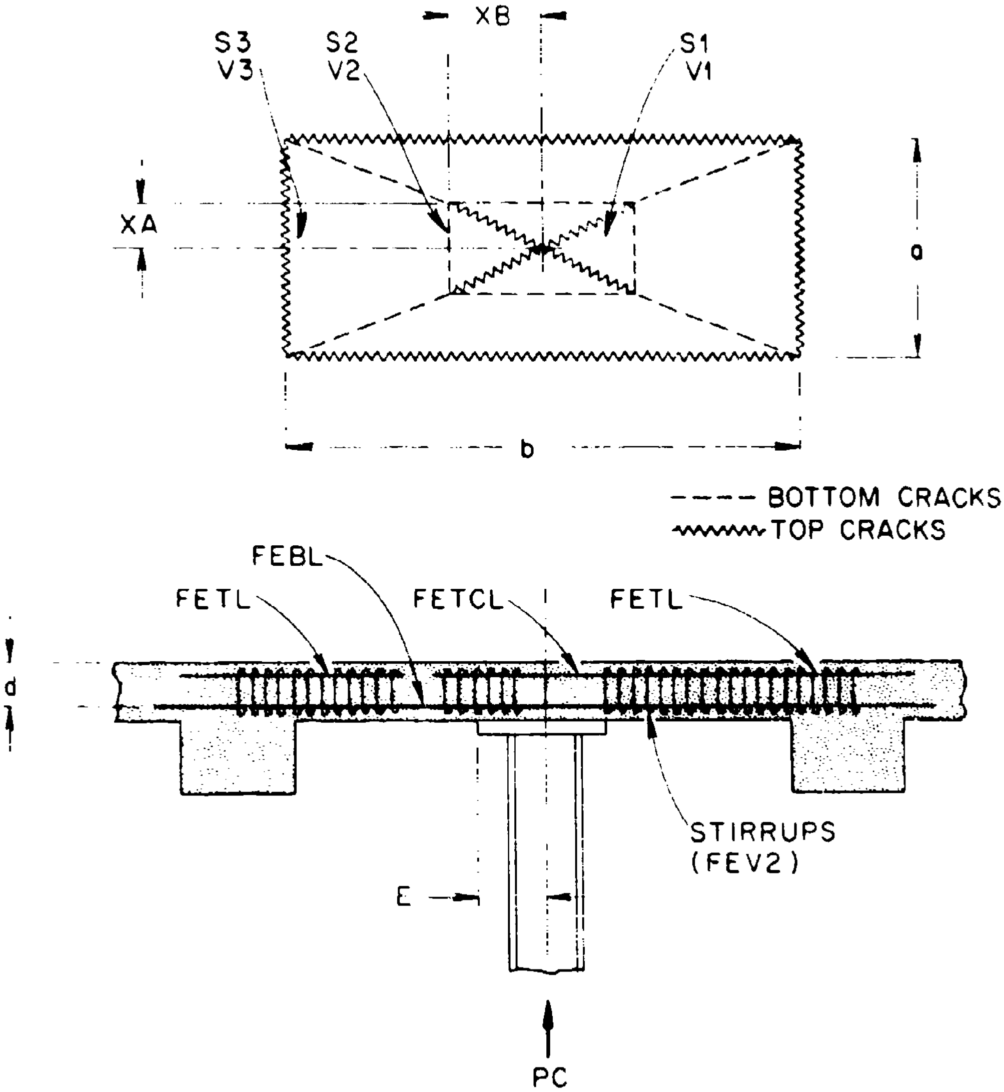


FETL = $\phi_{TOP\ LONG}$ = PERCENT OF STEEL

PC = LOAD ON COLUMN (lb)

FEV2 = $\phi_{V1}$ = PERCENT OF STIRRUP STEEL

Fig. 6.1. Concrete Slab Design.

steel bars, called stirrups, in the concrete slab. These are necessary to combat shear problem in design, but this technical feature is normally not seen in commercial slabs.

Detailed calculations of all the other structural members were not carried out. However, the costs of the beams and columns in this system are crudely evaluated by referring to the cost estimate of the previous study and allowing portable column placement to reduce beam span lengths. This offers smaller loads to the permanent concrete columns when they are designed for dual purpose. The Dallas truck tunnel rests on rock so no special footings need to be placed to receive the loads from the portable columns. Placement of a few additional reinforcing bars in the concrete floor of the tunnel should be all that is needed.

## 6.3 RESULTS

In the overhead structural system of the Dallas truck tunnel, the most expensive dual use structural item is the two-way slab with dimensions of 49 feet by 36 feet. Figure 2 shows slab thickness from the center of the reinforcing steel to the surface of the concrete for four different slab designs. One design was accomplished by applying a safety factor of 1.2 to a yield line evaluation of the two-way slab. This yield line curve is shown just below the standard design curve. It allows some reduction of thickness for the slab is allowed to crack in yield line analysis. By placing a portable column at the center of the slab and allowing slab cracking, the thickness is reduced about 50% compared to the standard design. The steel percentage was increased for the portable column concept. A yield line design of the slab with this higher amount of steel and no portable column is shown above the portable column curve. An example of thickness variation at 50 psi design load for the four design methods is as follows:

| Method | d(Inches) |
|---|---|
| Standard (0.5% Steel) . . . . . . . . . . . . . . . . | 36 |
| Yield line (0.5% Steel) . . . . . . . . . . . . . . . | 33 |
| Yield line (0.5% and 1.0% Steel) . . . . . . . . . | 27 |
| Portable column . . . . . . . . . . . . . . . . . . . . | 18 |

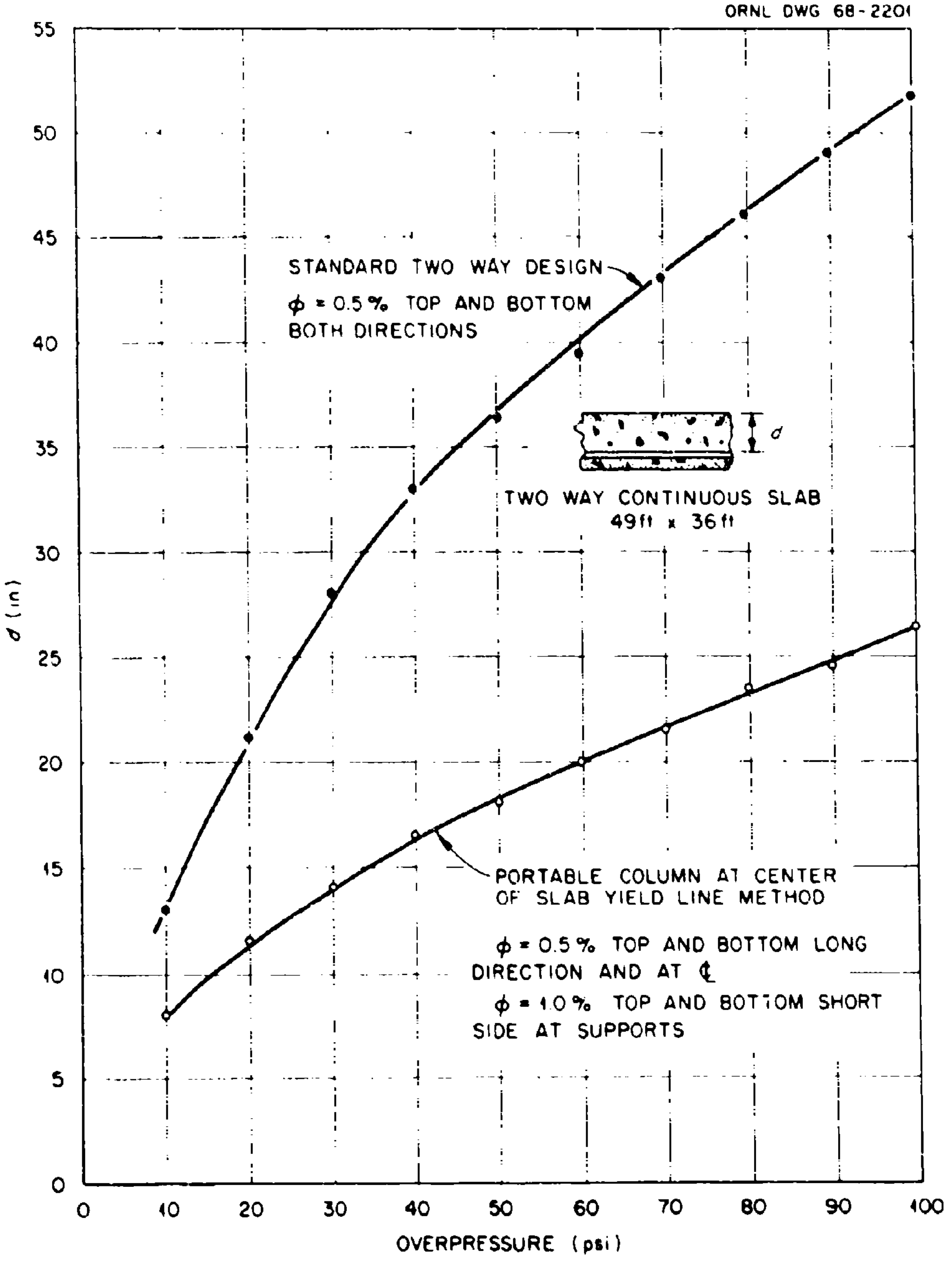


Fig. 6.2. Concrete Slab Thickness.

Quite a range of resistance to overpressure load for a particular slab thickness is shown in the following listing for d = 25 inches:

| Method | Resistance (psi) |
|---|---|
| Standard (0.5% Steel) . . . . . . . . . . . . | 26 |
| Yield line (0.5% Steel) . . . . . . . . . . . | 29 |
| Yield line (0.5% and 1.0% Steel). . . . . . | 42 |
| Portable column . . . . . . . . . . . . . . . . | 92 |

Figure 3 shows the total incremental cost for this dual use system. A significant saving can be realized when portable columns are incorporated in the design and when cracking is allowed. It was estimated that the overhead structural system costs would be reduced by about 50%. For this study, it was estimated that a 50% cost saving could also be realized by changing the design of the module structure. Blast valves, ventilation and refrigeration, blast doors, and the electrical expenses listed last year were not changed in Figure 3 for these values are independent of the method used in the structural system.

Figure 4 is the cost per shelter space for various levels of overpressure protection. These calculations are based on 35,000 and 70,000 shelter spaces.

## 6.4 CONCLUSION

There is a definite cost advantage in the use of portable columns for the Dallas truck tunnel and other wide span concrete structures. An advantage of this method is that the overhead structural system can be designed so the portable columns can be placed at a later time. Potential blast protection is built into the tunnel and for commercial purposes the long spans necessary for trucks to maneuver are still retained. The portable columns could be fabricated in advance of an emergency but placed when necessary. More conveniently the portable columns could be fabricated and stored in the tunnel or mounted on the ceiling and lowered into position. The mechanical complexities of this final concept have not been considered.

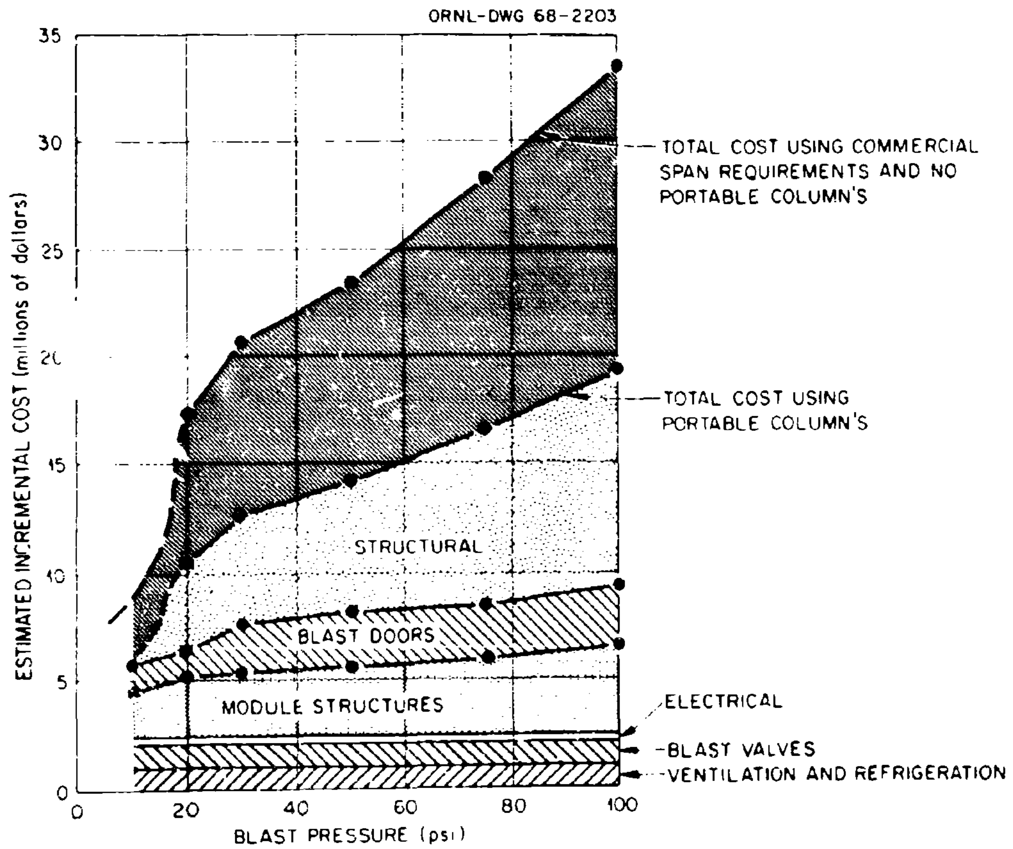


Fig. C.3. Total Incremental Cost.

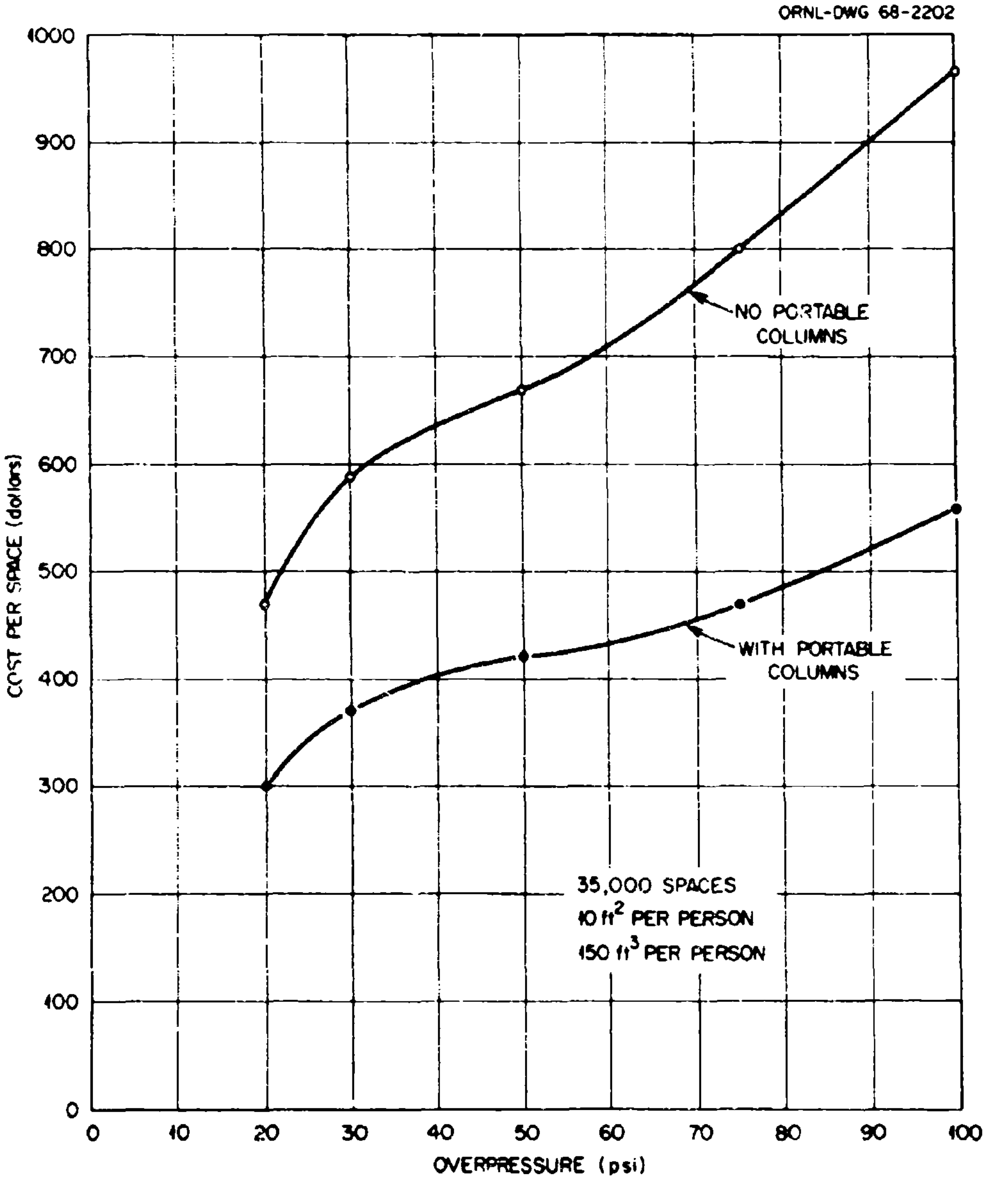


Fig. 6.4. Shelter Space Cost.

The Dallas truck tunnel concept is a specific case which lends itself to the use of portable columns for dual purpose blast shelter, but the technique should be applicable in new construction of apartments, department stores, schools, etc. Much shorter spans in commercial building can be expected than in a truck tunnel. In the below grade portion of a building with a reinforced concrete floor system some additional reinforcing bars could be placed, at very modest cost, in strategic locations so the system at a later time could most efficiently accept portable columns. These columns may be as lightweight as pipe columns which could be easily handled by one or two men. By this scheme, new buildings could be upgraded to allow higher blast protection.

The portable column approach could also be helpful in strengthening below grade floor systems in existing buildings so some higher degree of blast protection could be achieved. Calculation of the additional resistance obtained for an existing floor system is possible, but the accuracy of the calculation is difficult to assess. A test of this idea would be helpful.

It is possible to do an experiment of this kind at the White Plains Urban Renewal Area. This area is about 6 city blocks square and has many different types of buildings which are scheduled for demolition within the next several years. There will be extensive experimentation of these structures before they are torn down. One of the existing buildings which has a reinforced concrete floor system could be tested to appraise the load necessary to cause collapse, or near collapse. A test of this type could compare the strength of the floors with and without portable column support and evaluate the accuracy of existing methods of prediction.

The portable column approach appears to be a practical method to achieve higher blast resistance in structures at a small increment of the building cost. If a blast shelter system is ever deployed in the United States, this scheme should be incorporated into the overall solution to the blast protection problem.

## 6.5 REFERENCES

1. Annual Progress Report, Civil Defense Research Project, March 1966 - March 1967, ORNL-4184, Part I, p. 268.

2. Yield Line Theory, K. W. Johansen, published by William Clower and Sons, Limited, London, 1943.

3. Design Concepts for Adding 30-PSI Fallout to Occupied Buildings, Stanford Research Institute, 1962, SRI-IM-4075-3, p. iv-8.

4. Building Code Requirements for Reinforced Concrete, published by the American Concrete Institute, 1963.

# 7. MECHANICAL EQUIPMENT SHOCK TOLERANCE

C. J. Williams

## 7.1 INTRODUCTION

In last year's annual report a theoretical method was used to evaluate the response of a 106 kw diesel engine generator to a 100 psi overpressure wave. Such equipment might be installed in blast shelters for ventilation or other life support systems. At that time it was predicted that the equipment would still function in this shock environment except in sandy soil, based on an assumed shock tolerance of the equipment of 10 *g*. A shock response spectrum was used to make this evaluation with the critical mode of movement being in the vertical direction and a value of 19 cycles per second used as equipment vertical natural frequency. Results obtained this year show that more realistic evaluation would have been obtained if values of natural frequency ranging from 19 cycles per second to 100 cycles per second had been used.

On October 18, 1967, the 106 kw unit was shock tested at the Nevada Test Site (NTS). The upward shock from an underground nuclear explosion was used to model the downward shock from the overpressure pulse of an aboveground nuclear explosion. With the theoretical equipment vulnerability level at 10 *g*, for the first of a series of experiments, the engine generator was placed at a distance from the underground nuclear explosion which would give an estimated maximum ground shock of from 3 *g* to 8 *g*. The expected equipment response was to be in the lower values needed to bracket the equipment response which would cause the equipment to stop running.

For this test, the actual ground motion had a maximum upward acceleration of 3 *g* as was predicted. However, a second pulse, which was not predicted, occurred with a maximum load of 50 *g*. The 3 *g* upward ground motion would be the same as the downward acceleration from a 15 psi overpressure wave caused by an aboveground nuclear explosion. No

apparent damage occurred to the equipment from the initial shock. When the 50 g motion hit the generation the unit was damaged and stopped running.

The failure was caused by a cracked support bracket. This shear failure would be expected to be independent of the vertical direction (up or down) in which the load is applied. The 50 g upward ground motion is estimated to correlate to overpressures in the range of 100 psi to 150 psi from an aboveground burst. If this motor generator were used in a civil defense blast shelter exposed to a 100 to 150 psi blast wave, the equipment would have to be spring mounted or its components ruggidized.

## 7.2 TEST AND RESULTS

The shock test of the engine generator was on October 18, 1967, at the Nevada Test Site on Yucca Flat. Figure 1 is the general layout of the area for the experiment. Figure 2 is the plan of the concrete pad to which the motor generator set was attached during the test. The details of the pad reinforcing and the pad thickness are shown in Figure 3. Figures 4 and 5 are preshot photographs of the generator. The large tank shown on the right of the motor generator in Figure 5 is the reserve fuel tank which was necessary in order to keep it running for the prescribed amount of time. Gauges recorded the acceleration versus time history of the unit during the shock test. Sandia Corporation also furnished a monitor of the voltage output of the unit during the test so it could be determined whether the unit was running before, during, and after the ground motion shock.

The ground motion measurements were made fifty feet east of the motor generator (see Figure 1). Gauges for these measurements were buried at a depth of four feet. The combination of the data from the ground motion station and the data which shows the equipment response were necessary to determine equipment vulnerability.

The site plan (Figure 1) shows three steel pins driven into the ground near the equipment's concrete pad. They were used to determine

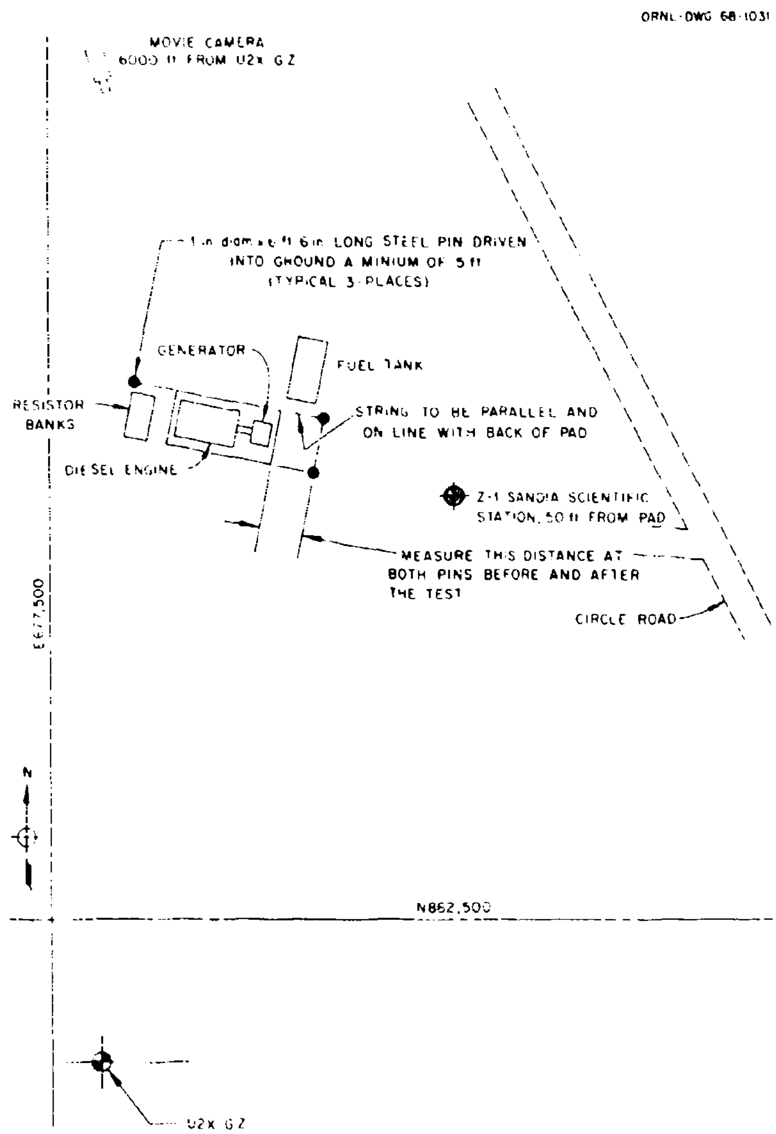


Fig. 7.1. Experiment Layout Plan.

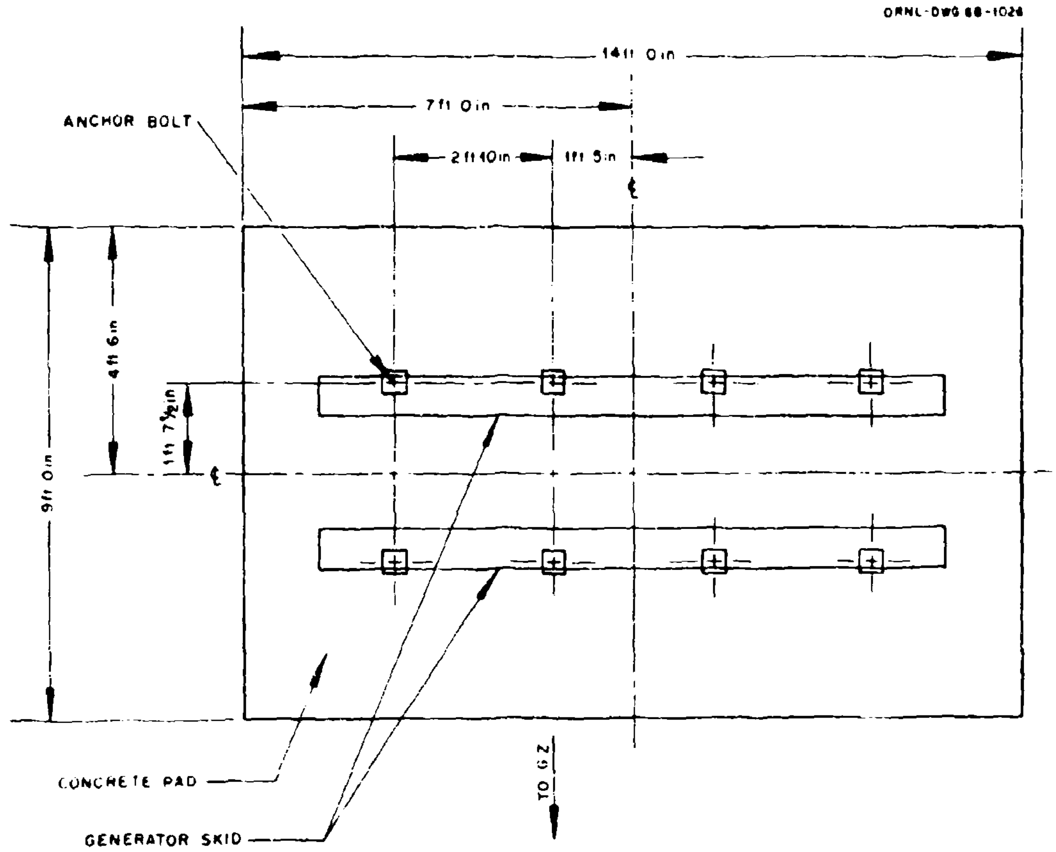


Fig. 7.2. Concrete Pad.

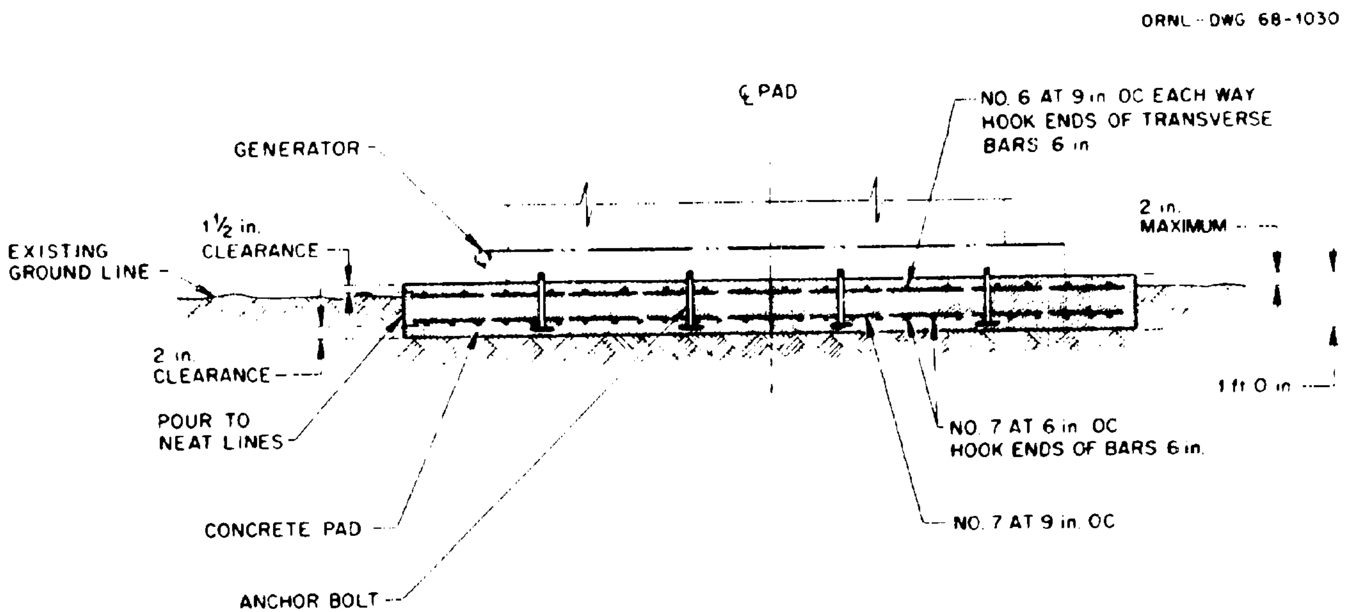


Fig. 7.3. Concrete Pad Details.


Fig. 7.4 Preshot Motor Generator Setup

Fig. 7.5 Preshot Fuel Tank Setup

the relative movement between the concrete pad and the surrounding soil. Measurements after the test showed no permanent gross relative movement of the pad.

Figure 1 shows the location of acceleration gauges which were buried four feet below ground surface and located fifty feet east of the engine generator. It was assumed that data from these acceleration gauges represented the ground movement at the site of the test equipment. The acceleration versus time traces for these gauges are shown in Figure 6. They are identified as follows:

| | |
|---|---|
| S4 | Sandia station, gauges buried four feet deep |
| AV | Vertical acceleration, positive signal is in upward direction |
| AR | Horizontal radial acceleration, positive signal is radially outward from surface zero |
| AT | Horizontal tangential acceleration, positive signal is $90^{\circ}$ clockwise from the horizontal radial acceleration when viewed above. |

There were two shocks from the underground detonation. The first could be approximately predicted but the second shock was of a more severe nature than was expected. This second shock was caused by a phenomenon called "slapdown" and it is described in this manner. As the shock wave approaches the surface of the earth, a layer of the earth's upper mantel is parted from the lower layer of material, a slabbing effect near the ground surface. This earth free falls back to the underlying solid surface and hits it with an impact. This is the "slapdown" effect, or as it is called in this report, the second pulse. Data of Figure 6 shows a maximum ground acceleration of 50 g, occurring during the second pulse and a lesser maximum ground acceleration of 3 g, which was during the first pulse.

There were acceleration gauges mounted on top of the generator end of the diesel generator set. Traces of these acceleration versus time gauges are shown in Figure 7. They are identified as G4 gauges with AV, AR, and AT connotations being the same as for the S4 gauges. The high noise levels on the generator mounted gauges are due to the machine's

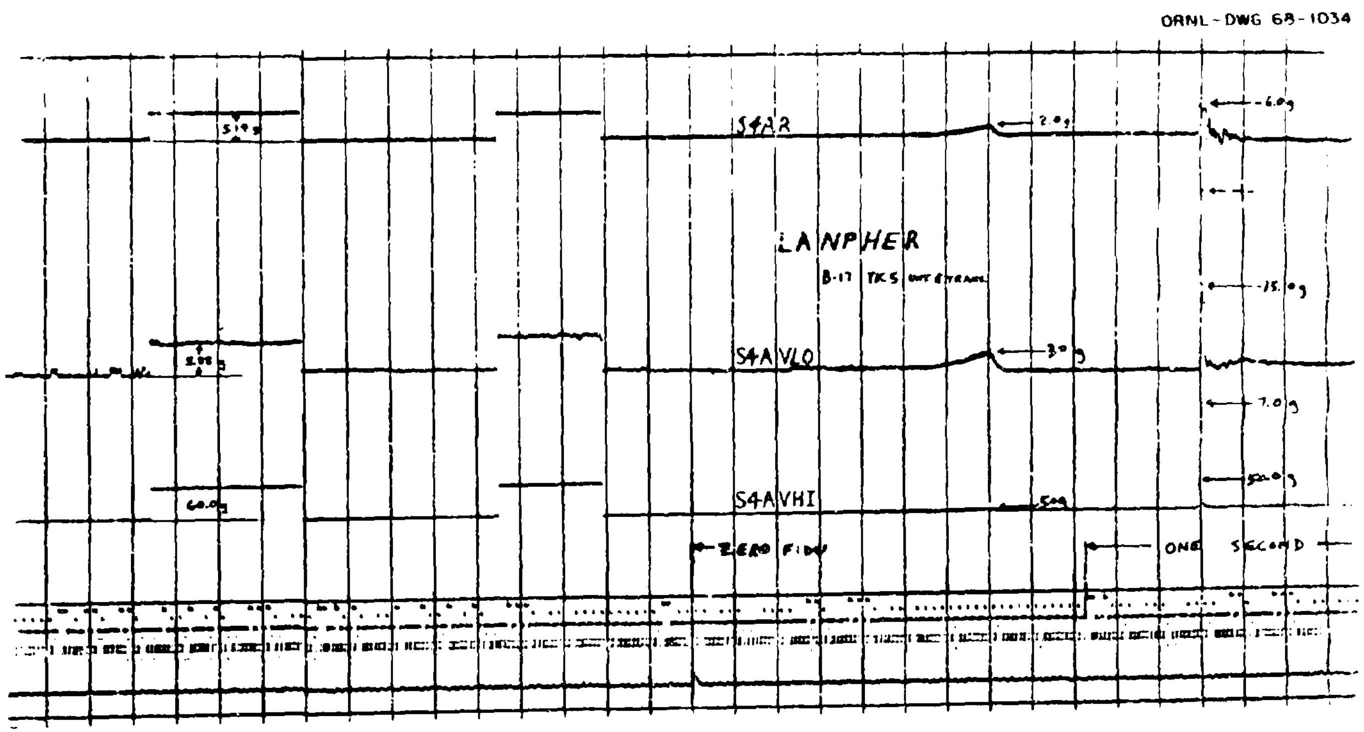


Fig. 7.6. Acceleration Gauge Data-Ground Motion.

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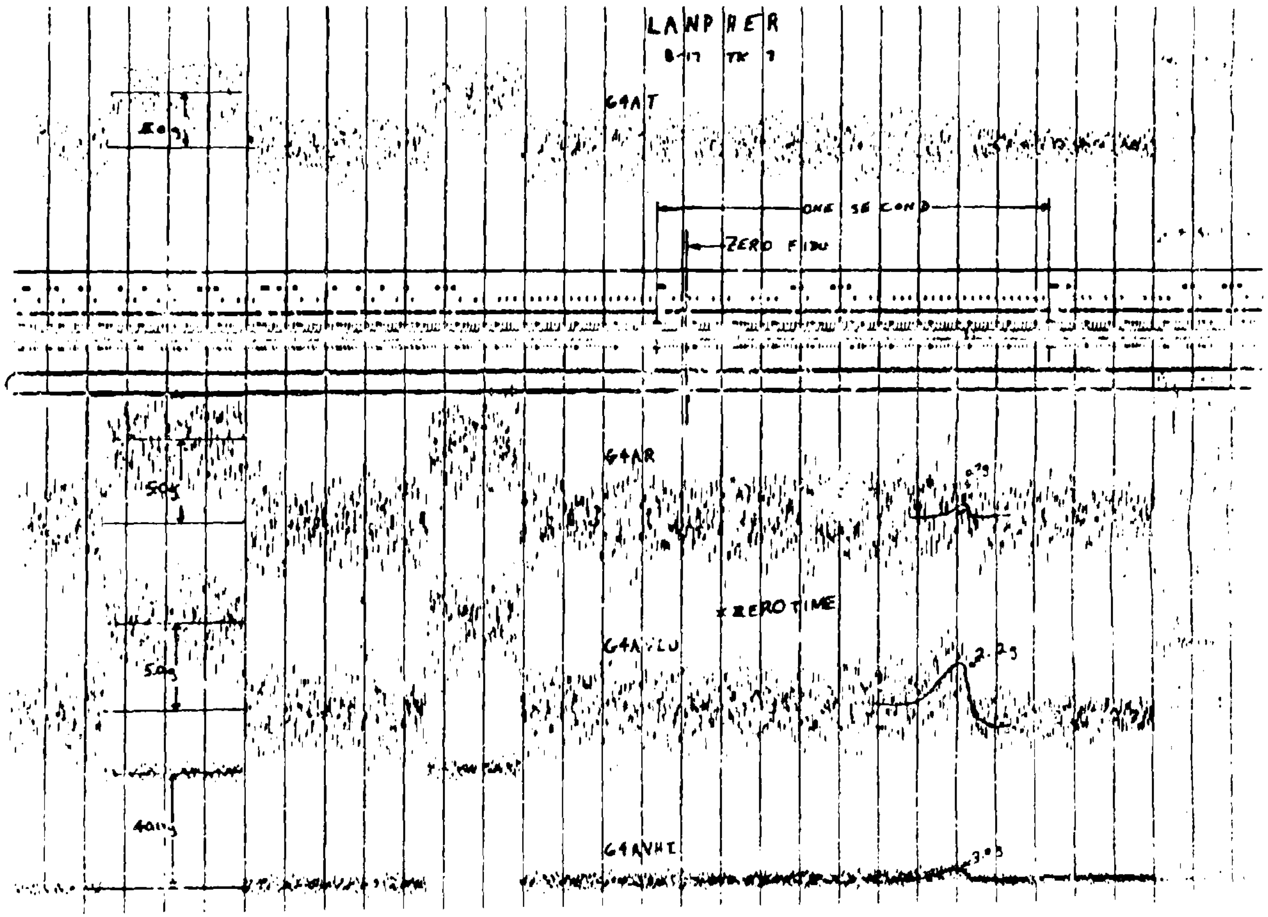


Fig. 7.7. Acceleration Gauge Data-Generator Motion.

vibration. With the generator turned off the noise levels were very acceptable. The vertical maximum acceleration of the generator for the first pulse is about 3 g. It is not possible to determine from the graphs what the acceleration of the generator was during the second shock pulse. As can be seen there is much interference at the time of the second shock which occurred 0.6 seconds after the first shock.

The voltage output of the generator was monitored during the test. Figure 8 is a trace of this output from zero time until the second pulse hit the equipment. The equipment was functioning properly during the first shock pulse but the voltage began to drop off when the second pulse, labeled "slapdown," struck. Voltage output was recorded for about 25 seconds after slapdown, at which time the readings became zero.

Damage to the test equipment is shown in Figures 9 through 11. Primary damage was caused by cracking of the support to which the generator was attached. This piece and its cracks are shown in Figure 9 and Figure 10. The failure of the support allowed the engine to rotate vertically away from ground zero, causing more damage. Figure 11 shows this rotation of the equipment. (Oil spilled on the concrete pad before the shock test was made.) As can be seen in Figure 12 the connection leading to the engine from the radiator was torn loose. Rotation at this point was about 4 inches. The coupling between the generator and the diesel engine was also damaged as can be seen in Figure 13. Damage was also experienced by the fan blade as it hit the fan blade guard housing which surrounds it.

A slow motion picture of this experiment was taken from a distance of 6000 feet north of zero point. Figure 1 shows the location of the camera relative to the engine generator. The movie showed the ground wave passing the diesel generator. However, the camera was so far from the test equipment and the light was so inadequate, it was not possible to determine quantitatively how far the generator was displaced or when the "slapdown" occurred.

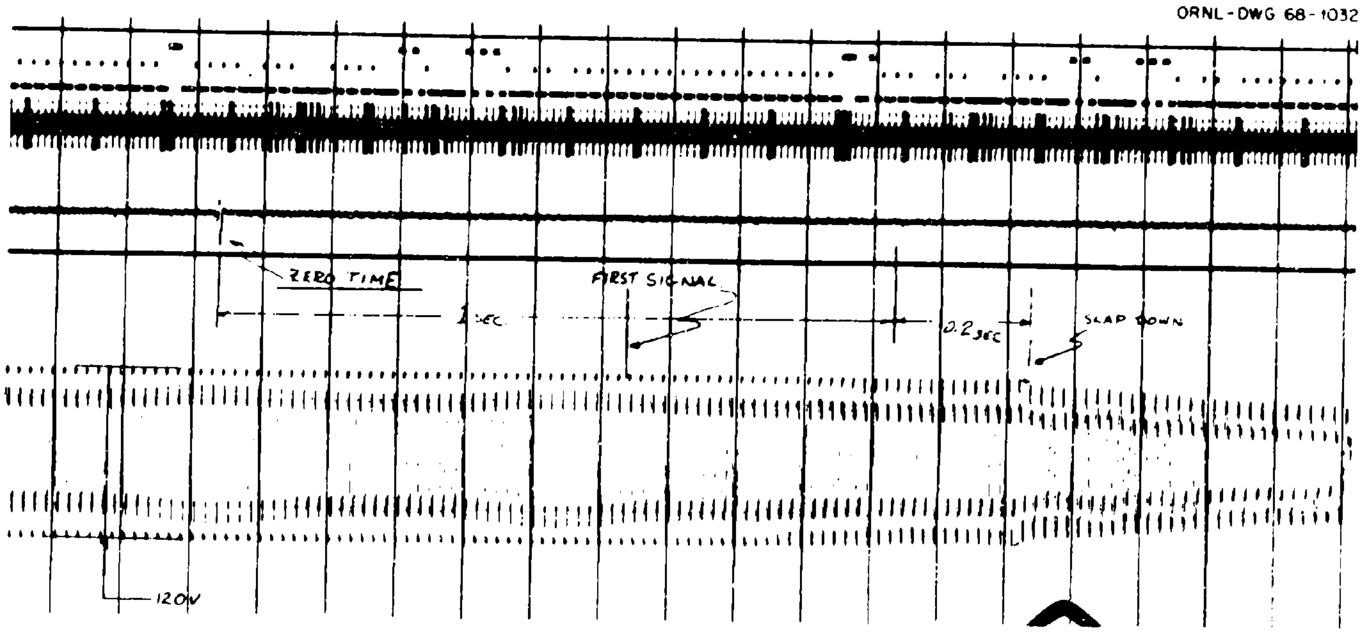


Fig. 7.8. Generator Voltage Output.

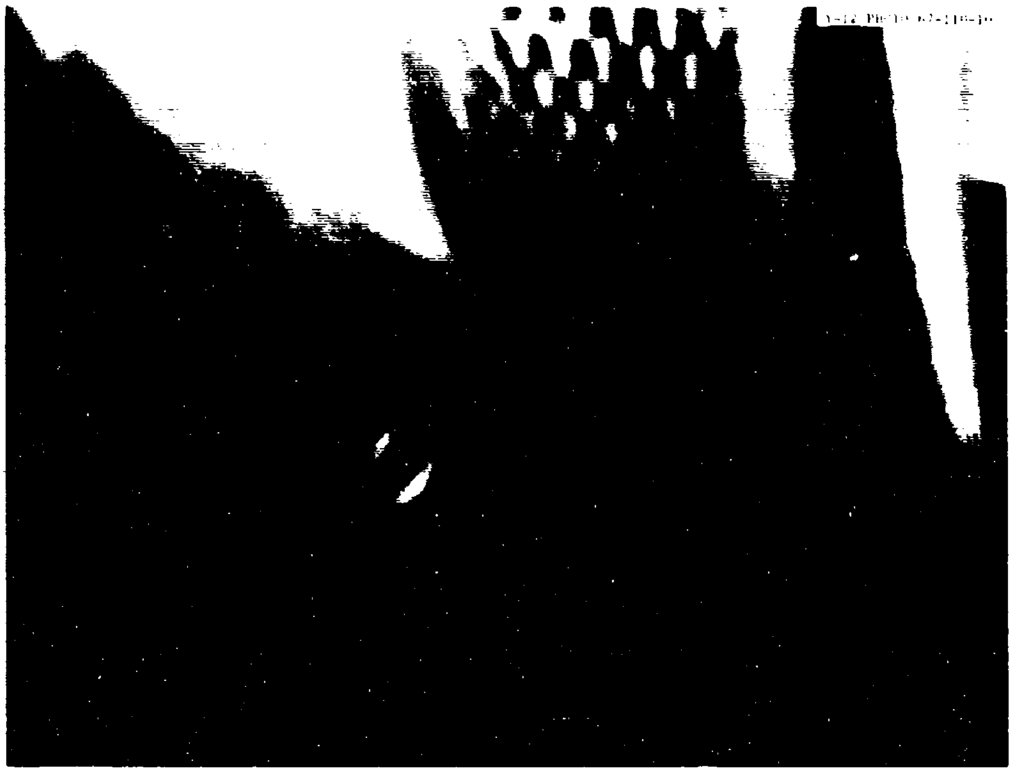

Fig. 7.9 Generator Support Crack on Side Away From Surface Zero


Fig. 7.10 Generator Support Crack on Side Toward Surface Zero

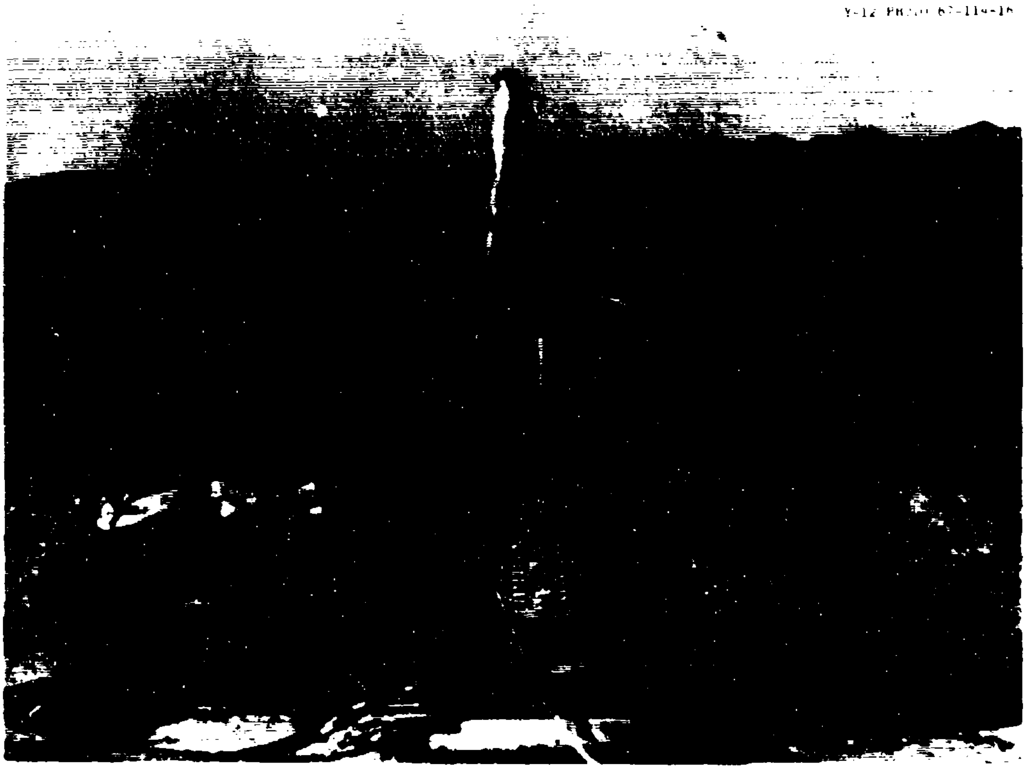

Fig. 7.11 Engine Generator (Postshot) Showing Clockwise Rotation


Fig. 7.12 Radiator Connection Damage

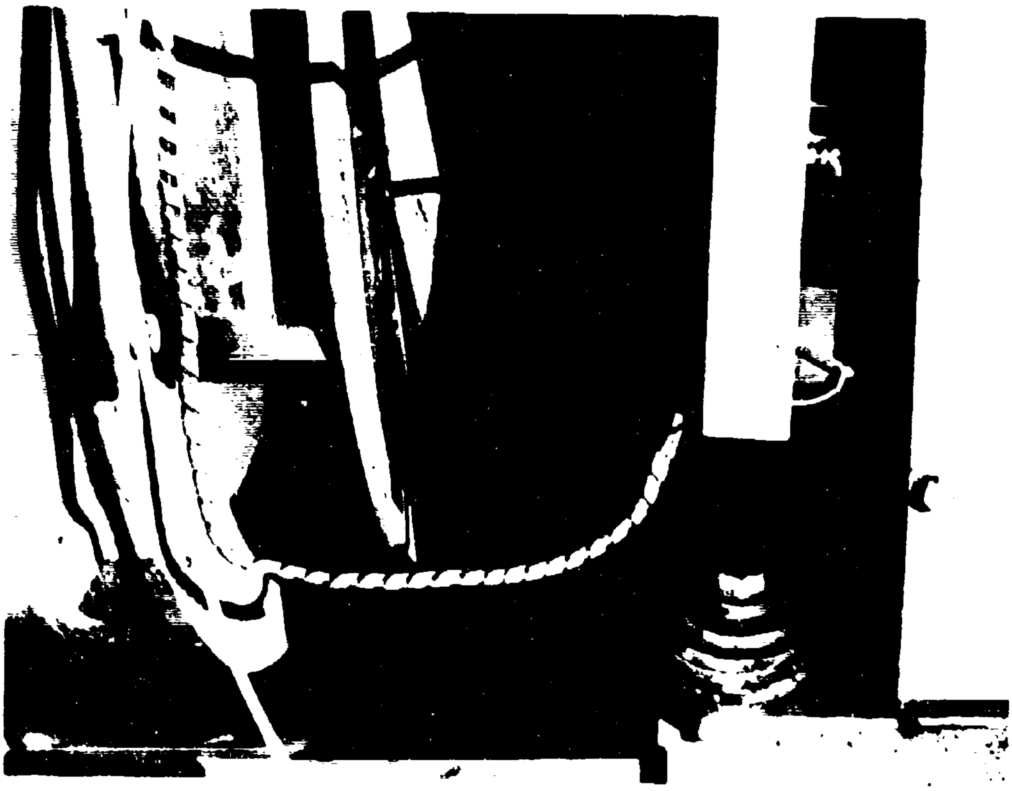

Fig. 7.13 Engine To Generator Coupling Damage

## 7.3 INTERPRETATION

The acceleration versus time charts developed from gauges buried four feet below ground at the site of the engine generator are shown in Figure 6. In order to get a clearer picture of the ground acceleration in the vertical direction, the readings as shown on gauges S4AVLO and S4AVHI have been used to reconstruct the approximate acceleration motion of the soil in Figure 14. From this acceleration data the free field velocity and displacement have been constructed.

Values of $a_{max}$, $v_{max}$, and $d_{max}$ are taken from the data shown in Figure 14. Calculated values of A, V, and D are used in construction of the response spectra for the first pulse and the second pulse. Figure 15 shows these two spectra.

With the damage occurring to the motor generator being caused by the vertical component of the shock, the value of the natural frequency of the engine generator as established in last year's report, can be taken as 19 CPS. However, this resonant condition is attributed to the vibrations in the rubber mounts which are located at the generator end of the unit. When damage occurred to the equipment it can be assumed that these rubber mounts completely compressed and another natural frequency in the vertical direction became primary. There is no record of what this frequency might be, but knowing the transverse frequency is 30 CPS, and visualizing physically the geometry of the diesel generator, it can be assumed that this second vertical frequency is greater than 30 CPS and possibly as high as 100 CPS.

The first pulse response spectrum shows that the 19 CPS to 100 CPS natural frequency range gives a reading bounded by an acceleration of 6 g's. The second pulse response spectrum is primarily bounded by an acceleration of 100 g's in the natural frequency range of the diesel generator. For both the first and the second pulse it is assumed that acceleration controls the response of the equipment to the ground motion.

It is possible to correlate the ground motion equipment response from this underground nuclear explosion to an equivalent ground motion equipment response caused by the overpressure wave of an aboveground

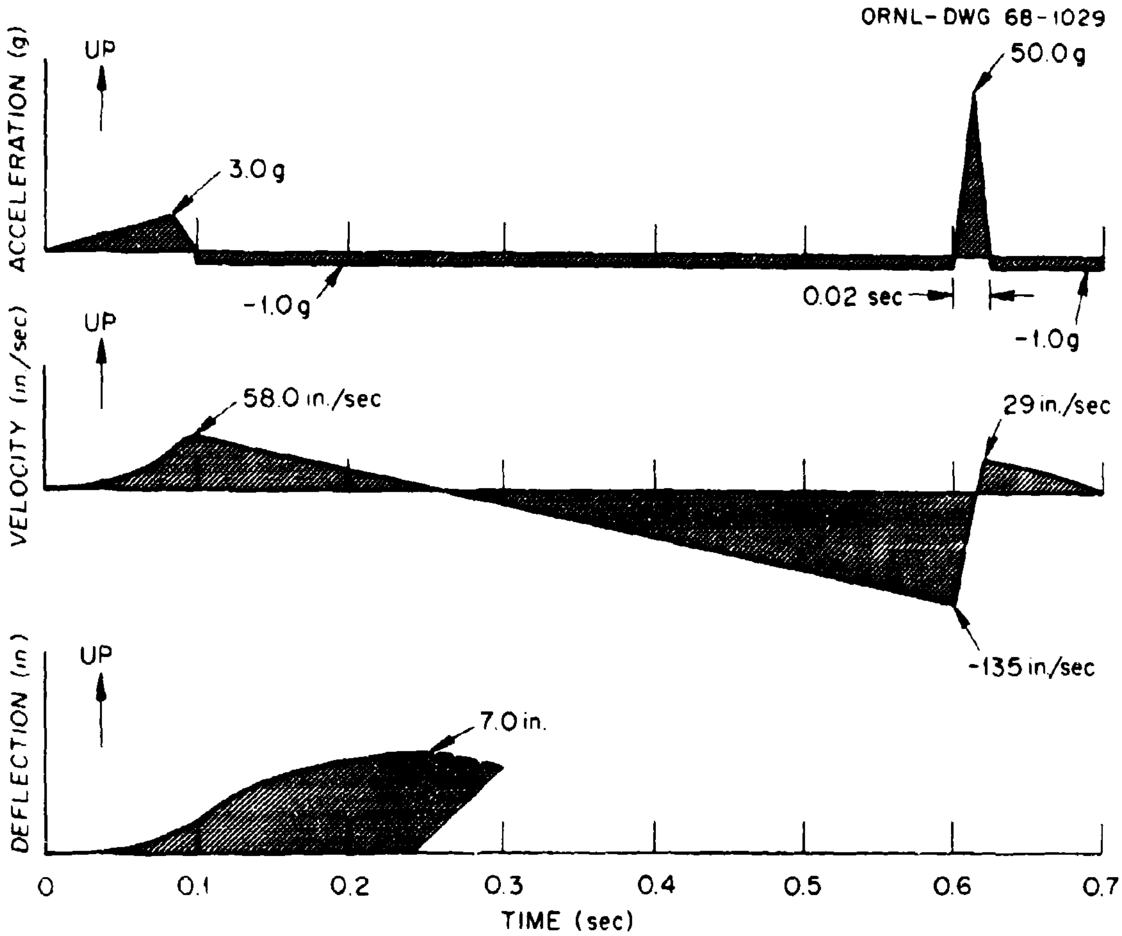


Fig. 7.14. Estimated Ground Motion Data.

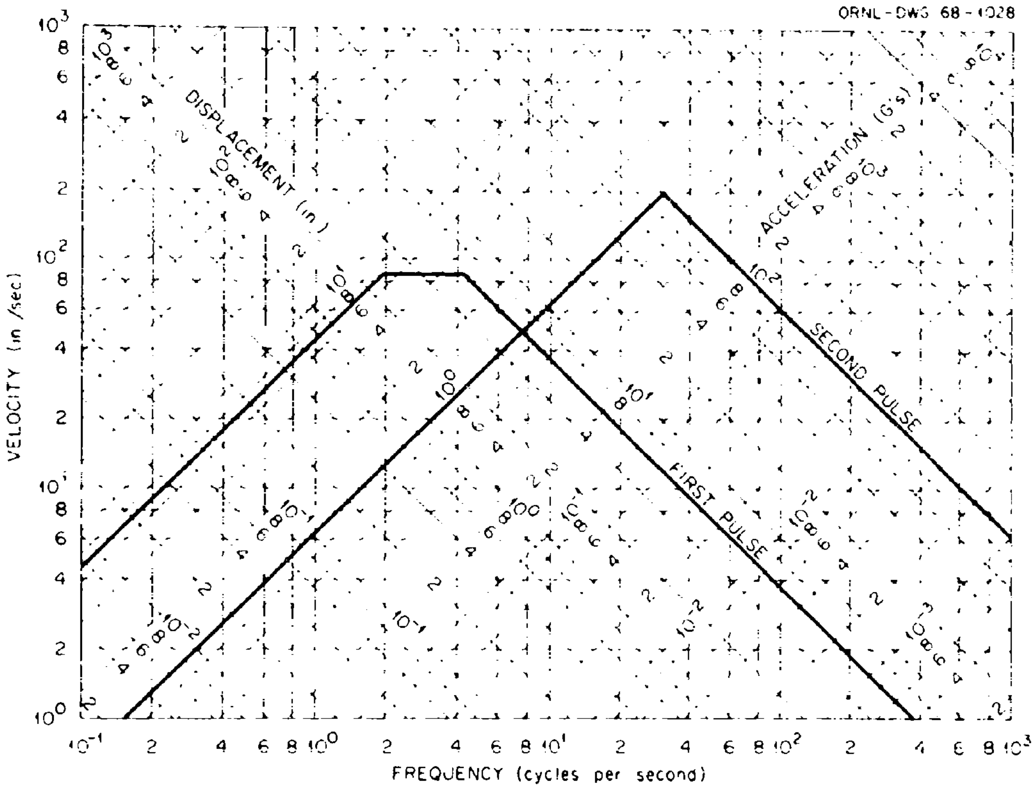


Fig. 7.15. Shock Response Spectra.

nuclear explosion. The spectrum response to these two underground pulses dictate that the equipment is acceleration sensitive. For this report the prediction of the response of the generator due to an aboveground burst is based on placing the diesel engine generator inside a civil defense shelter buried 15 feet deep. Figure 16 is a plot of maximum free-field soil particle acceleration for some soil variations and for overpressures up to 200 psi from an aboveground nuclear explosion. The acceleration of 3 g's and 50 g's on Figure 16 correlate to the response spectrum acceleration 6 g for the first underground pulse and a response spectrum acceleration of 100 g for the second underground pulse. A horizontal line drawn on Figure 16 at 3 g and 50 g gives a method of determining the overpressures, for various soil conditions, which give the same shock environment as the diesel engine generator was exposed to at NTS. We conclude that this 106 kw unit would not be damaged at the 15 psi range from an aboveground nuclear explosion, but would be damaged and stop running at overpressures in the range of 100 psi to 150 psi.

## 7.4 CONCLUSIONS

Shock tests conducted at the Nevada Test Site can determine the vulnerability of large pieces of equipment. For this shock test, calculations show the first pulse to which the engine generator was exposed was about the same shock environment as is produced by a 15 psi overpressure wave from an aboveground nuclear burst. The assumption is that the mechanical equipment is in a pipe with a diameter of 8 feet buried with about 11 feet of cover. For this condition no apparent damage would occur to the generating unit. The time dependent record of the voltage output of the generator experienced no fluctuation during the first shock. Calculations for the second pulse show that the underground explosion created a shock environment similar to overpressures ranging from 100 psi to 150 psi. Damage was extensive to the equipment when it was exposed to this shock environment. The generator voltage output record shows this shock caused the generator to stop running.

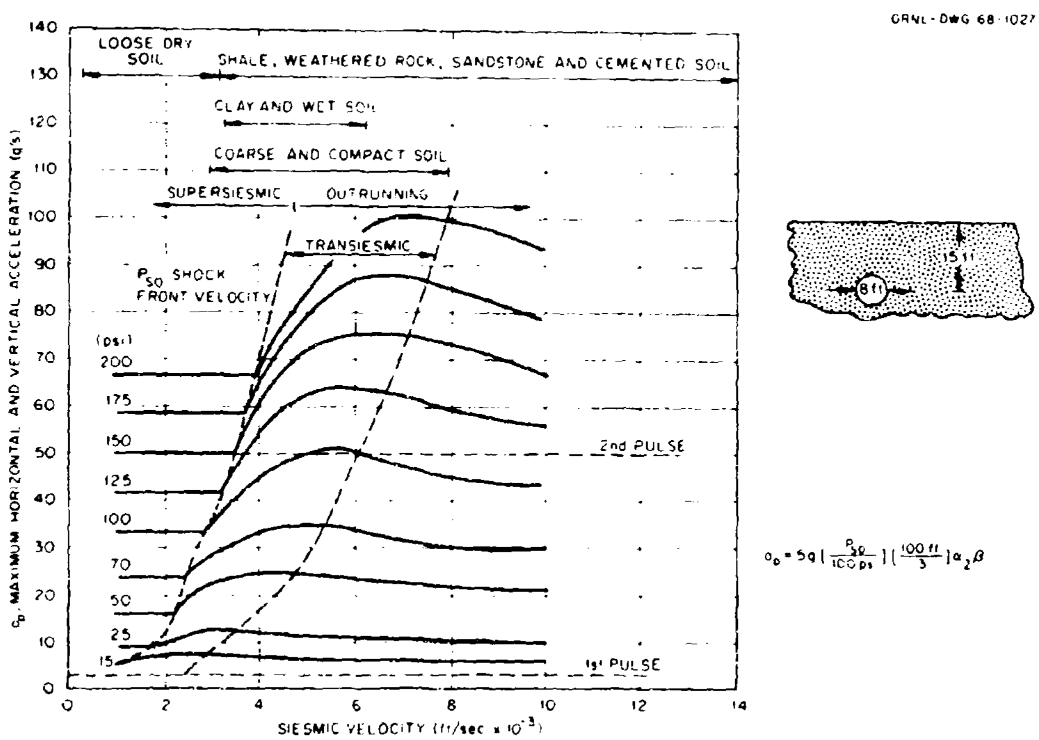


Fig. 7.16. Particle Acceleration At Depth of 15 Feet.

This type of information will be helpful in the design of hardened civil defense shelters. For example, this 106 kw engine generator will not have to be shock isolated or ruggidized in a 15 psi shelter system. However, if it were placed in a shelter designed to withstand overpressures from 100 psi to 150 psi, then the equipment will have to be shock isolated or the equipment components will have to be strengthened so they can resist the shock caused by ground motion.

The slapdown effect which occurred at the NTS during this experiment magnified the maximum ground motion acceleration from 3 g's to 50 g's. With the main shock wave coming from the underground nuclear explosion this phenomenon is possible in the soil at NTS. In civil defense blast shelters the main shock force will very probably come from above the shelter. For this reason the slapdown effect should not occur in blast shelters.

# 8. RADIANT STERILIZATION OF BIOLOGICAL AEROSOLS

C. V. Chester

## 8.1 INTRODUCTION

One possible approach to the protection of people from pathogenic biological aerosols is to kill the organisms in the air by some form of radiant energy in or near the visible part of the spectrum. Since the particles of a biological aerosol absorb this energy much more effectively than air, it should be possible to select an energy source that, under the proper conditions, is capable of killing the organisms with minimal heating or other effects on the air.

In order to be useful, any scheme proposed must be capable of killing the most refractory organisms known, the spores of certain pathogenic bacteria and fungi. This requirement demands exposures well beyond the usual practice in the design of such commercial equipment as ultraviolet sterilizers. Preliminary calculations are presented for each radiation source to show the problems involved.

## 8.2 ENERGY REQUIREMENTS

### 8.2.1 Ultraviolet

By extrapolating the data of Buttolph (2), the 2400 Å to 3000 Å germicidal UV irradiation required to kill spores is about 2000 $\mu$-watt-min/cm$^2$, or about 0.05 cal/cm$^2$. Unfortunately for our purposes, this radiation is absorbed very strongly by ozone in the upper atmosphere. Were it not for this absorption, large-yield thermonuclear weapons exploded at an appropriate high altitude would be a very convenient method of sterilizing large areas with virtually no damage to the ground. In clear weather, one would have a very effective defense against pathogenic biological aerosols.

As will be shown in Section 3.3.2, even applied to ventilating ducts, this exposure has an unacceptably large concomitant air temperature rise from present mercury vapor tubes. Irritating concentrations of ozone would also be produced.

### 3.2.2 Thermal and Visible Radiation

Thermal and visible radiation kill by heating the spore enough to bring about some denaturing chemical reaction such as protein co-agulation, dehydration, or pyrolysis of some essential molecules in the spore. The temperature required depends on the time of exposure.

Decker (1) reports effective sterilization (less than $10^{-6}$ survival) of B. globigii spores by exposure to 218°C for 24 sec., 246°C for 10 sec., and 302°C for 3 sec. in an air sterilizer.

As will be shown subsequently, effective heating and cooling times of less than $10^{-5}$ seconds can be achieved with a Q-switched laser. Extrapolation of Decker's data on an Arrhenius plot (log time vs. reciprocal absolute temperature, Figure 1) is not helpful, since the reciprocal temperature goes past zero at about $3 \times 10^{-5}$ seconds, a physical absurdity. Obviously the simple first-order reaction implied by this plot will no longer be applicable to such extremes of temperature.

One can only conclude that for such short times, energy corresponding to a temperature rise of several hundred degrees centigrade will be required. One might expect the temperature to be less than red heat, 600°C, and more than 400°C. Mainly for the purpose of selecting experimental equipment, we will assume that 500°C is an interesting neighborhood to investigate.

The energy fluence required to heat absorbing 1 micron particles in a vacuum 500°C is 0.05 cal/cm$^2$, assuming the particles have the specific heat of water. Unfortunately, the particles may not be perfectly absorbing, and we are interested in particles in air at about standard density.

<u>Energy Absorption by Aerosol Particles</u>

The process of light scattering and absorption by small particles is complicated and beyond the scope of this discussion. Van de Hulst

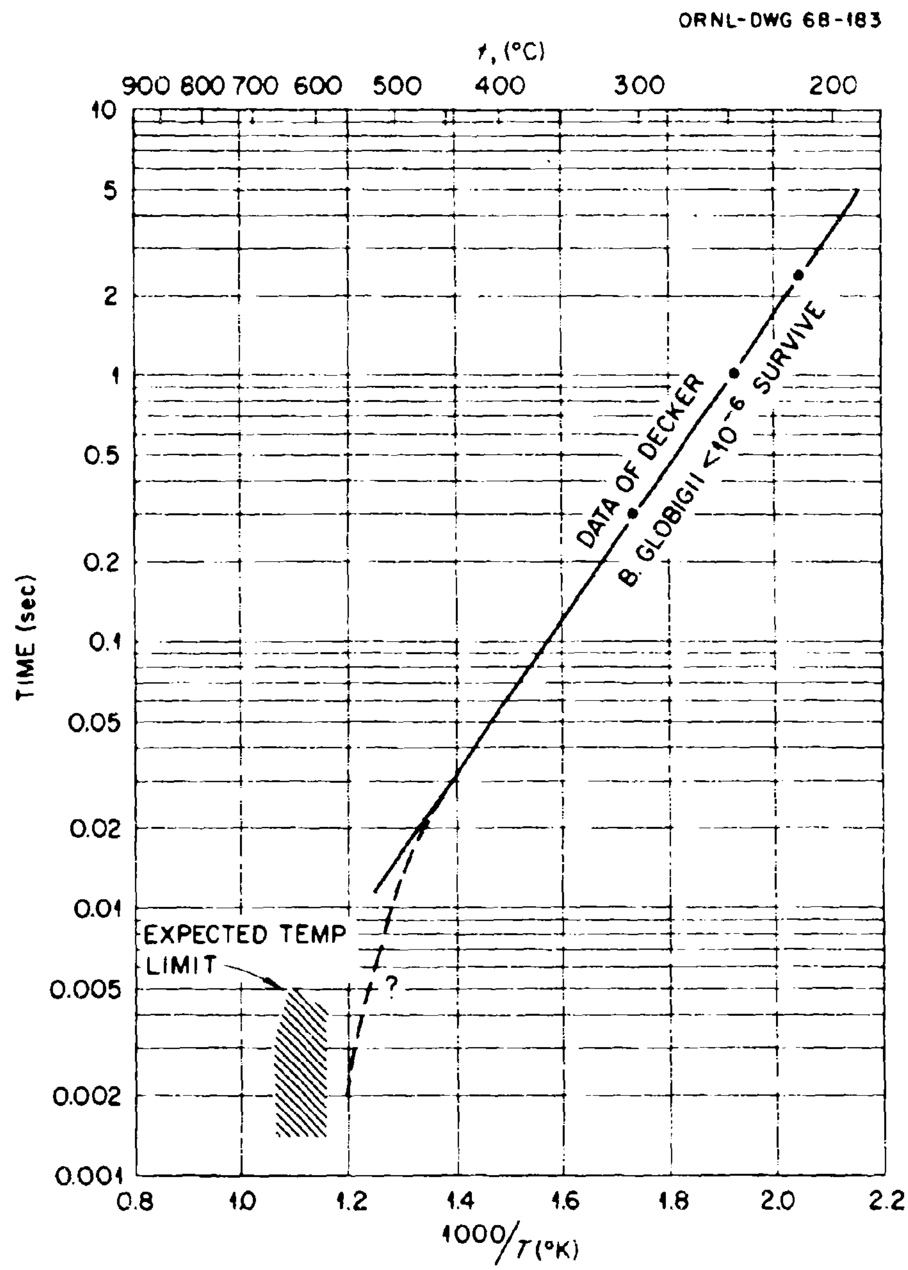


Fig. 8.1. Log Exposure Time vs Reciprocal Absolute Temperature to Kill B. Globigii Spores.

has written an authoritative text on the subject (3). Plass (4) has calculated the absorption efficiency, which is the same as absorbtivity, for Mie absorption for small particles with a variety of values of the complex index of refraction, $n_1 - in_2$. His results are reproduced in Figure 2 for particles with $n_1 = 1.33$, that of water.

For 1-micron particles and 7000 Å, $2\pi a/\lambda$ has a value about 4. The value of $n_2$ for water is very small. It will be much larger for a spore, but so far no estimates have been found. For small values of $n_2$, $\leq 10^{-2}$, the absorption efficiency is proportional to $n_2$. It is quite possible that an effective value of $n_2$ can be found in the neighborhood $10^{-2}$.

Calculations of Mie scattering, and especially the notion of a complex refractive index, apply rigorously to homogeneous particles. Spores are not optically homogeneous, having much internal structure. They also contain no free water, and hence the real component of the index of refraction will be different, probably larger, than 1.33. However, the general form of the dependence of absorption efficiency on wavelength will not be much affected by these discrepancies. From Figure 2 we would expect an absorption efficiency of about 0.1 for 1-μ spore in 7000 Å radiation. If the 10.6 μ infrared from a $CO_2$ laser were used, the efficiency would be down one or two orders of magnitude, and in a region very sensitive to particle size.

## Heat Transfer between Aerosol Particles and Air

The principal difficulty in trying to heat aerosol particles in air lies in the excellent thermal contact between the particles and a much larger mass of air. The surface to volume ratio of particles is very large, and the transfer is aided by the divergent geometry of the heat path in air.

A fair approximation to the description of radiant heating of the particles can be made by assuming them to be perfectly conducting spheres of mass $M_1$, specific heat $C_1$ and radius a in contact with a medium of density $\rho$, heat capacity C and conductivity K. The radiant energy input is assumed to be a heat source Q cal/sec in the sphere.

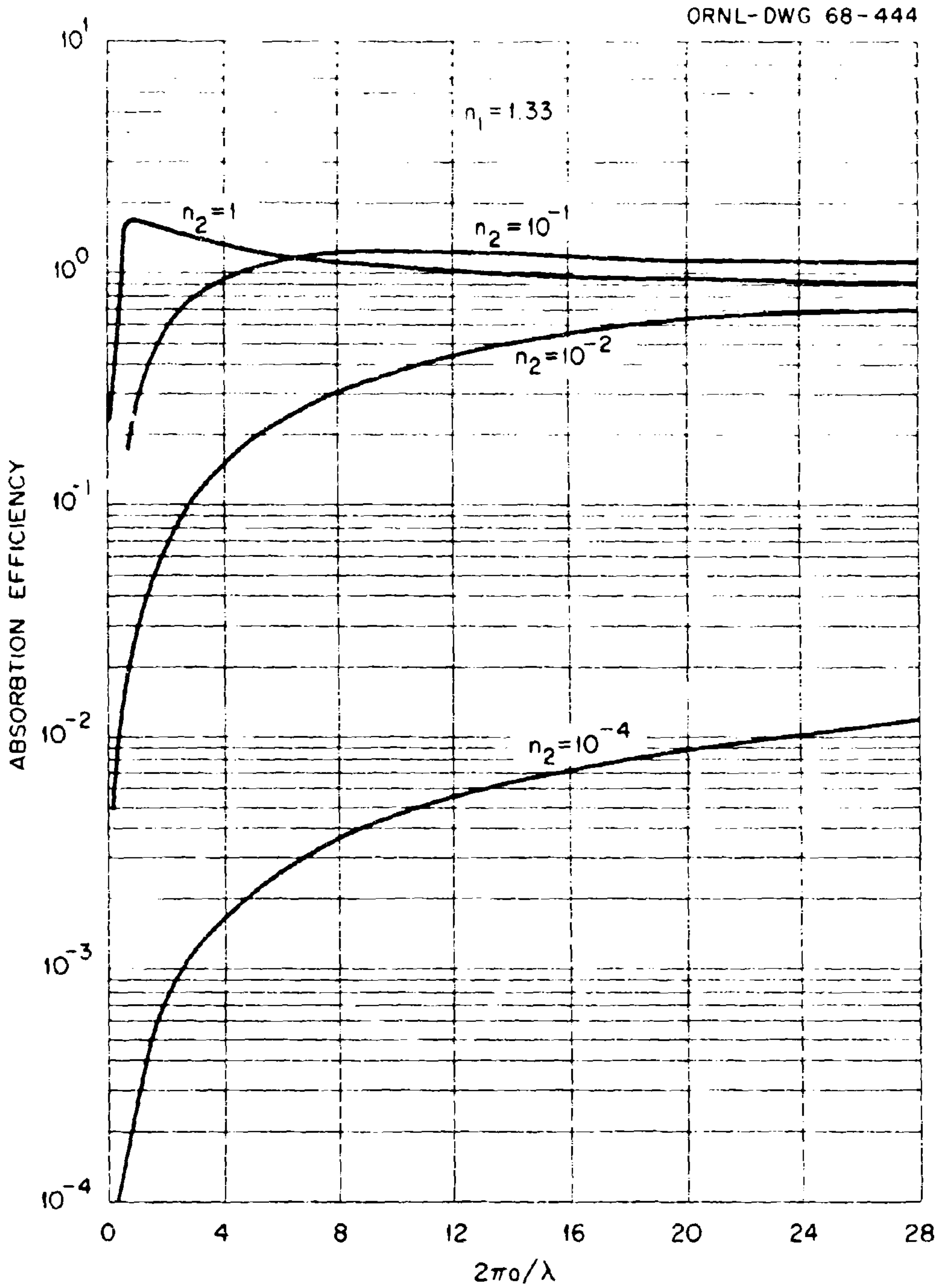


Fig. 8.2. Absorbtion Efficiency vs Normalized Particle Diameter.

The solution to this problem is given in Carslaw and Jaeger (5), and for the temperature $V_1$ of the sphere is

$$V_1 = \frac{Q}{4\pi aK}\left\{1 - \frac{2k}{\pi}\int_0^\infty \frac{e^{-\kappa u^2 t/a^2}\,du}{u^2\,[(u-k)^2 - k]}\right\}$$

where $k = \dfrac{4\pi\rho Ca^3}{M_1 C_1}$

$$\kappa = \frac{K}{\rho\ C}$$

The series approximation for long times $t > \dfrac{a^2}{\pi\kappa}$ is

$$V_1 = \frac{Q}{4\pi Ka}\left\{1 - \frac{a}{(\pi\kappa t)^{1/2}} - \frac{a^3\,(2-k)}{2k\pi^{1/2}(\kappa t)^{3/2}} + \ldots\right\}$$

If the radiant flux density $\Phi$ is $\dfrac{Q}{\pi a^2}$,

$$V_1 = \frac{\Phi a}{4K}\left\{1 - \frac{a}{(\pi\kappa t)^{1/2}} + \ldots\right\}$$

The term outside the bracket is the steady-state solution for this geometry.

The relevant physical constants for water and air at 100°C are

| | K, cal/cm², sec °C/cm | ρ, gm/cm³ | C cal/gm, °C | κ, cm²/sec |
|---|---|---|---|---|
| Water | $1.50 \times 10^{-3}$ | 1.0 | 1.0 | $1.50 \times 10^{-3}$ |
| Air | $7.6 \times 10^{-5}$ | $1.3 \times 10^{-3}$ | 7/29 | .24 |

For 1-micron particles after $10^{-7}$ sec., $V_1 \approx \frac{\Phi}{3}$ where $\Phi$ is in cal/cm², sec. and $V_1$ is in degrees centigrade.

## 8.3 STERILIZATION IN DUCTS

### 8.3.1 Approximation of Illumination Intensity in a Reflective-Wall Duct; UV Sources

In connection with the sterilization of air in a ventilating duct, it is necessary to estimate the variation of intensity of the sterilizing radiation when the walls are made highly reflective.

Single Line Source

Consider a volume enclosed between two planes of absorbtivity $\epsilon$, reflectivity $1-\epsilon$, and separation w. This space is to be illuminated by a line source of intensity $I_o$ measured at unit distance. A slice of the duct parallel to the line source at a distance x and thickness $\Delta x$ will be illuminated by the sum of rays from the source which have undergone n reflections from the wall where n - 0, 1, 2, 3, ---. Each of these reflected rays may be "unfolded" at the reflecting planes to give a diagram similar to Figure 3.

A given ray undergoing n reflections and traveling a distance r to reach the duct element $\Delta x$ arrives with an intensity $\frac{I_o(1-\epsilon)^n}{r}$. From the geometry of Figure 3,

$$n \approx \frac{y}{w} = \frac{x\text{Tan}\theta}{w} \qquad (1)$$

The total illumination of the element $\Delta x$ is the sum of all the rays reaching it which is

$$I_x = 2\sum_{n=0}^{n} \frac{I_o(1-\epsilon)^n}{r_n}\Delta n \qquad (2)$$

For large values of n and x, we can approximate the sum by the integral

$$I_x \cong 2\int_0^{\pi/2} I_o(1-\epsilon)^{\frac{x\text{Tan}\theta}{w}} \frac{r\text{ Cos }\theta\text{ d }\theta}{w} \qquad (3)$$

if we let $\Delta n \approx \frac{\Delta y}{w} \approx \frac{r\text{Cos}\theta d\theta}{w}$. (4)

The reflectivity term can be expanded by the binomial series to give

$$I_x = \frac{2I_o}{w}\int_0^{\pi/2}\left[1-\frac{x\text{Tan}\theta}{w}\epsilon + \left(\frac{x\text{Tan}\theta}{w}\right)\left(\frac{x\text{Tan}\theta}{w} - 1\right)\epsilon^2 - \dots\right]\text{Cos}\theta d\theta \qquad (5)$$

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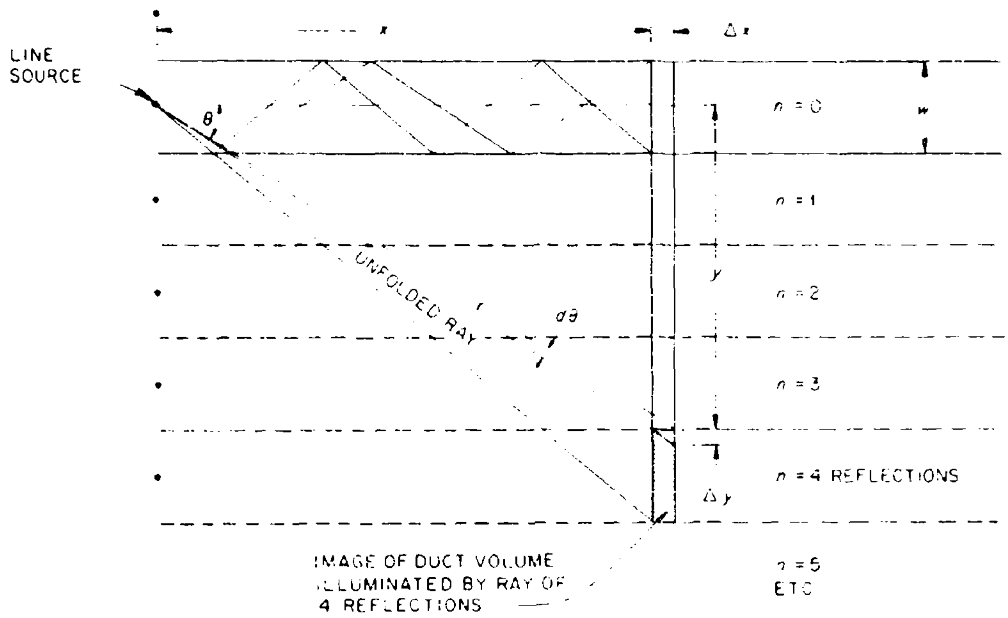


Fig. 5.3. Geometry of Illumination in a Reflective Duct.

Neglecting second and higher terms

$$I_x \approx \frac{2I_o}{w} \int_0^{\pi/2} \text{Cos}\ \theta\ d\ \theta - \frac{2I_o \epsilon x}{w^2} \int_0^{\pi/2} \text{Sin}\ \theta\ d\ \theta \qquad (6)$$

$$I_x = \frac{2I_o}{w} (1 - \frac{\epsilon x}{w}) \qquad (7)$$

An Array of Line Sources

If the single line source is replaced with a vertical array of m line sources as in Figure 4, a slight modification of the expression is required. The problem can be reduced to that of part 1 by considering each line source to be separated initially from the adjacent by a perfectly reflective wall. Since the light from each source does in fact reflect from the real walls at some time their finite absorbtivity can be distributed over the imaginary walls. Then the expression for a single source can be used, replacing $\epsilon$ with $\frac{\epsilon}{m}$ and w with w/m

$$I_{x,m} = \frac{2mI_o}{w} (1 - \frac{\epsilon x}{w}) \qquad (8)$$

Reflective End Walls

If the extent of the duct is limited by reflective walls parallel to the light source, they increase the flux in the duct. If the flux in the open case falls linearly with distance from the source as given by Equations 7 and 8, and shown in Figure 5, the light flux reflected from the end will continue to fall in the same way as it goes back toward the source. The sum will be a constant, equal to twice the incident intensity at the wall less the amount absorbed by the wall. For a duct of distance h from the source array to a parallel wall,

$$I_{h,m} = \frac{2mI_o}{w} (2-\epsilon) (1 - \frac{\epsilon h}{w}) \qquad (9)$$

These calculations are directed toward a low-pressure mercury arc as a source of ultraviolet radiation. This source is also an almost perfect absorber of UV from an external source. Therefore, only two

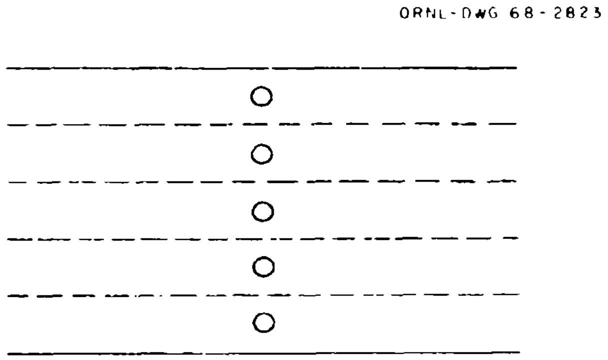


Fig. 8.4. Line Sources in a Parallel-Wall Duct

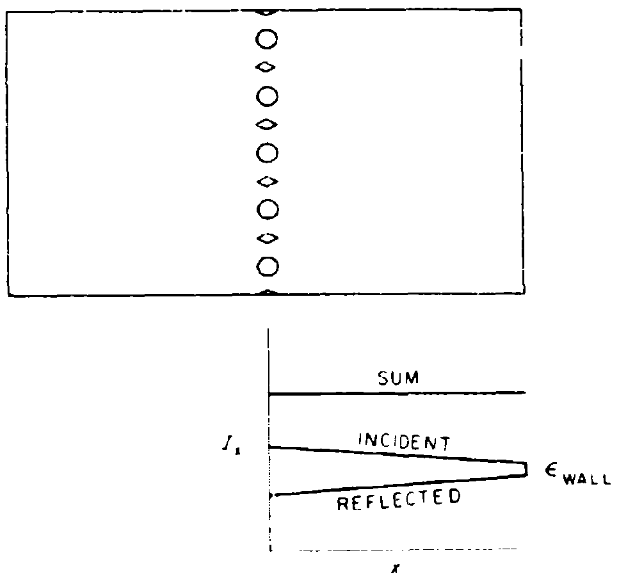


Fig. 8.5. Line Sources and Light Intensity in a Reflective End Wall Duct.

passes of the radiation through the duct are considered. Everything that gets back to the source is reabsorbed.

### 5.3.2 Design of a UV Sterilizer for a Ventilation Duct. Economic Considerations

Figure 6a is a sketch of an array of UV tubes and reflectors in an air duct. The intertube reflectors (Figure 6b) prevent absorption by adjacent tubes before radiation has made its transit of the duct. The arrangement chosen is optimized for minimum heating of the air given a 24" high duct with a wall emissivity of 0.32. The optimum width is 75 inches.

To obtain the 2000 $\mu$-watt-min/cm$^2$ estimated to give over 99% kill of anthrax spores, the velocity in the duct must be kept to 7.65 ft/min with a single bank of G36T6 tubes. If usual ventilation practice were followed, a duct this size would be carrying about 3000 cfm, and would require 30 banks of tubes serially down the center of 90 feet of duct. In either case if the air were required to carry off the heat of the tubes, it would be heated 18.6°F or about 10.3°C.

Such heating would be completely unacceptable in the summer without mechanical refrigeration.

It is possible that some arrangement of UV-transparent windows might permit the use of a separate stream of air to cool the tubes. The walls could also be separately cooled. However, this would be complicated and add to the already considerable expense of the installation.

This structure could be made a little more resistant to blast damage, perhaps to 5 psi, than absolute filters by enclosing the tubes in transparent pipes. However, exceeding the strength of the tubes would result in a spray of mercury vapor and glass being blown into the structure!

Absolute filters protected by flash-actuated blast values are a much cheaper solution to the same problem.

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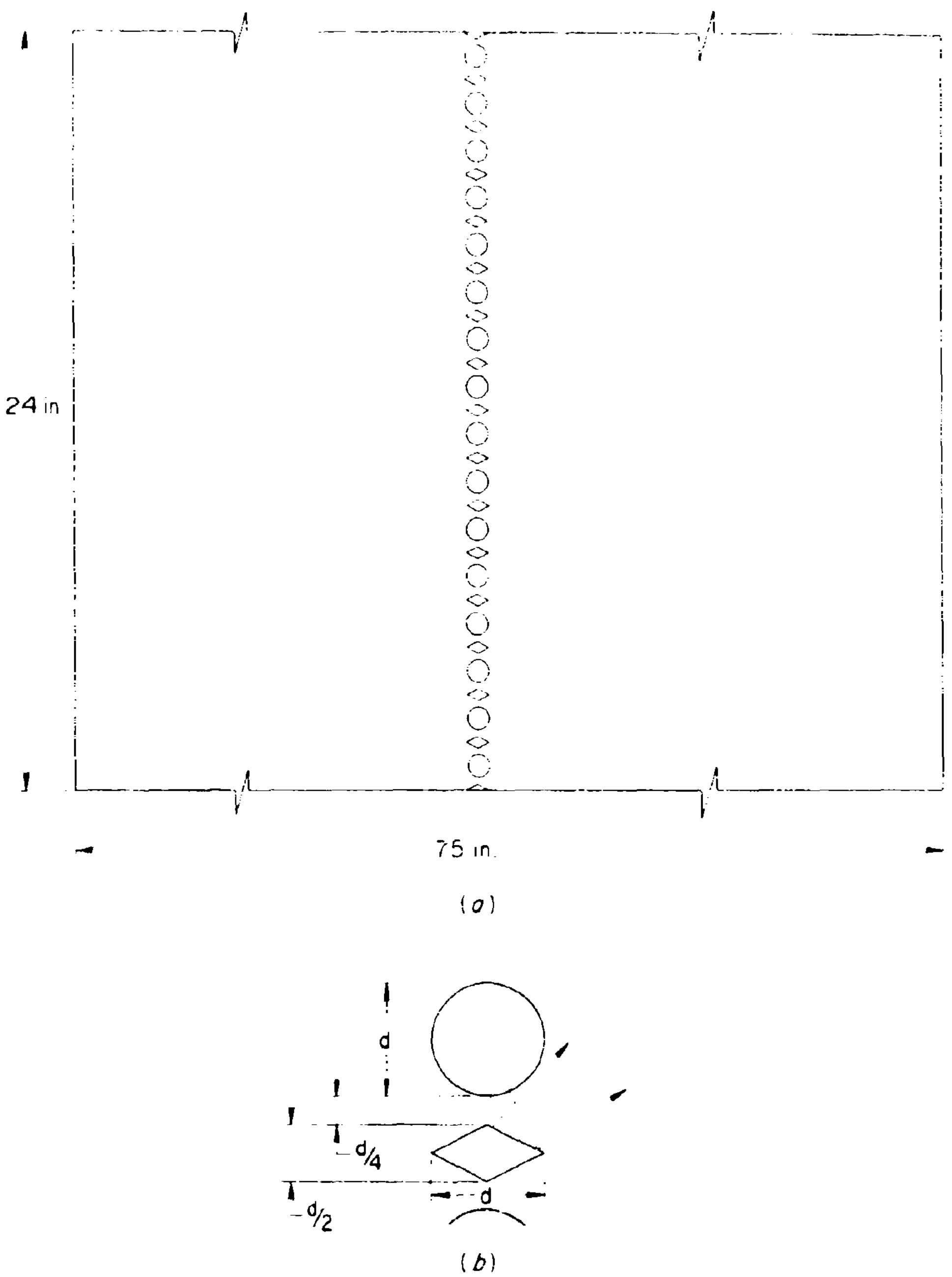


Fig. 8.6. (a). Duct Cross Section. (b). Inter-Tube Reflector.

### 8.3.3 Economics of a Laser Source as a Sterilizer

A pulsed laser in its normal mode may be considered to have a pulse width of 1 millisecond. If an energy flux density of 15000 cal/sec, $cm^2$ is required over an area of 1 $cm^2$, a 60-joule pulse will be about the right size.

A Q-switched laser can have a pulse width under 20 nanoseconds. For the same flux density, a pulse of 1.2 millijoules will be required. The 60-joule laser above operating Q-switched will have an output pulse of about 1 joule, and will be able to deliver the required power over an area of about 1000 $cm^2$ or 1 $ft^2$.

All this assumes that the spores can be killed by heating to an average temperature of 500 $^oC$, even if only for $10^{-7}$ seconds. This is real terra incognita on the time-temperature curve of Figure 1. The volumetric energy densities and deposition rates are comparable to those of detonating TNT. The kill mechanism may be some spalling or fracture phenomenon, rather than protein coagulation or denaturation. The experimental investigation of this aspect promises to be highly educational.

At this embryonic stage of the study, an economic comparison of laser sterilization with absolute filtration appears to favor filtration. Given a sterilizing beam of 1 $ft^2$ cross-sectional area, a ventilation system could be designed using reflective ducts that might sterilize as much as 50,000 $ft^3$/min. The installed cost of absolute filters to do the same job is estimated at $12,500 ($250/1000 cfm). The purchase price of the laser alone is $10,000. The additional ducting and optics would probably run the cost up to about $50,000. A filtration system would be required to keep the reflective surfaces free of dust.

However, the sterilizing system could be made very blast resistant. The laser can be installed behind a high-pressure window. The limiting structure is probably the reflective surfaces. If deformed, they will not permit the beam to evenly sweep the duct volume.

The experimental investigation of flash sterilization of biological aerosols is worthwhile to learn more about the properties of biological aerosols. With the energy flux densities available from relatively inexpensive ($<\$10^4$) pulsed lasers, regions of the time-temperature sterilization curve can be explored that were physically impossible a few years ago. The sensitivity of the more fragile organisms is completely unknown. With the paucity of existing data, some surprises might be expected.

## 8.4 LARGE AREA STERILIZATION WITH NUCLEAR WEAPONS

To heat 1 micron particles and minimize heating the rest of the environment, the radiant flux density rather than fluence must be maximized. At some acceptable value of the thermal fluence ($cal/cm^2$), high values of radiant flux density can be achieved by either (1) bursting a small-yield weapon close by or (2) bursting a large-yield weapon at altitudes above 15 miles. Jones et. al. (6) give the following relations in an unclassified report:

Below 10 mi., the maximum power or flux is

$$P_{max} = \frac{f\ w}{2.07\ t_{max}} \qquad \text{megatons/sec}$$

where f is the fraction of yield emitted as thermal radiation, taken as 1/3, w is the yield and $t_{max}$ the time of the second maximum. The constant 2.07 is obtained by integrating the thermal pulse curve in Glasstone (7). This constant approaches unity for bursts above about 20 miles.

The equation for $t_{max}$ given by Jones et.al. is

$$t_{max} = 0.32\ w^{0.42} e^{-0.09h} \text{ sec}$$

for w in megatons and h in miles. The flux can be converted to the radiant flux density (cal/sec, $cm^2$) by dividing by the area and substituting for $t_{max}$:

$$\Phi = 1.5[illegible] \cdot 10^{[illegible]} \left(\frac{w}{x^2}\right)^{[illegible]} \frac{e^{-.54x}}{x^{[illegible]}} \text{ cal/cm}^2\text{, sec}$$

The fluence, or total radiant energy delivered to a unit area at distance x is

$$\Phi t = \frac{fw}{4\pi x^2} \text{ megatons/km}^2$$

If $\Phi t$ is, for example, 10 cal/cm$^2$, a relation for the thermal flux density as a function of burst altitude for a constant fluence of 10 cal/cm on the ground is obtained:

$$\Phi_{10\ \text{cal}} = 21.0 \frac{e^{-.54x}}{x^{0.34}} \text{ cal/cm}^2 \text{ sec}$$

For values of x over 30 km, the value of the constant should increase to 120.3 with some sort of smooth transition between 10 km and 30 km. This will account for the constant of 2.[illegible] that drops out of the power term as the pulse shape changes from the low-altitude form with a minimum to the high altitude form without. As can be seen in Figure 7, the curve of $\Phi t$ is concave upward.

At low values of x, where the desired power levels are obtained close to small bursts, the prompt nuclear radiation is very large. At larger values (>1000R) the intensity of the prompt gamma radiation can be approximated by

$$I = 1.2 \times 10^6 \frac{w}{x^2} e^{-1.77x} \text{ rem}$$

where as before w is in megatons and x in kilometers. The expression is obtained by replotting some of the data in Glasstone (7).

At the 10 cal/cm$^2$ thermal fluence level, a peak thermal flux density of 1000 cal/cm$^2$, sec can be obtained 35 meters from a 5-ton yield. The gamma level is over 4000 rem at this point. If the thermal radiation level is held at 10 cal/cm$^2$, and the burst altitude and yield

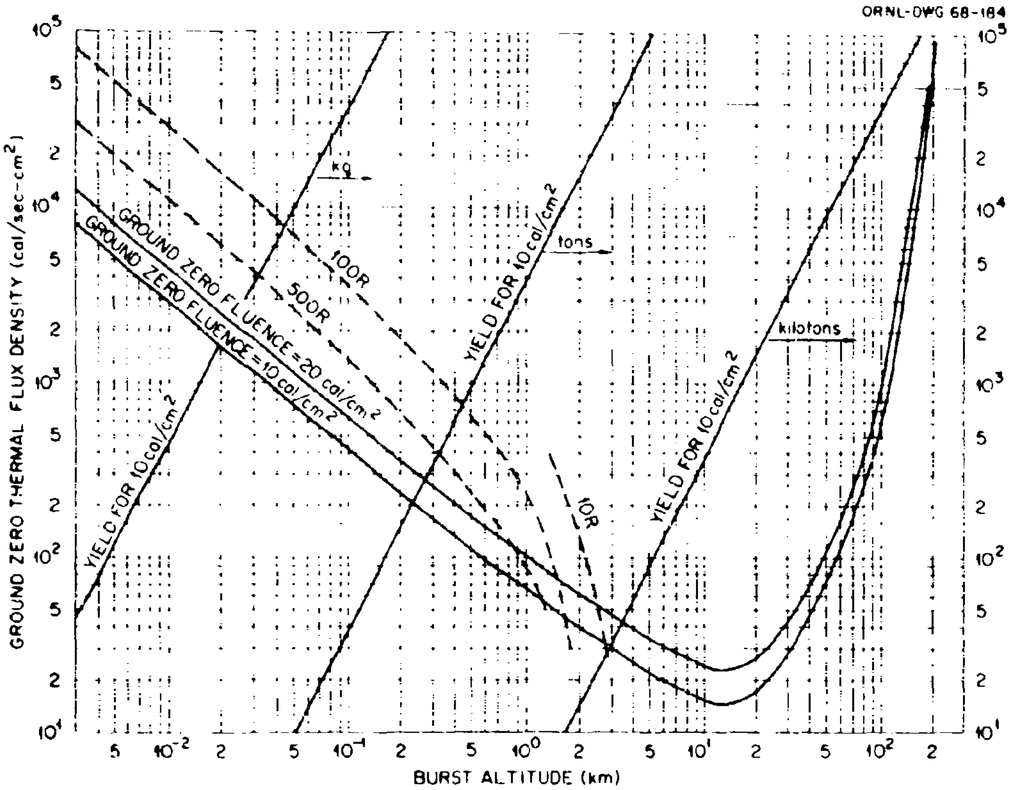


Fig. 8.7. Thermal Flux vs. Burst Altitude for Constant Thermal Fluence.

are increased, the gamma dose doesn't fall below 10 rem until one gets to a 10 kt yield at 1.05 km. Ten rem is reached at 2.3 km from a 20 kt burst. In this region, the thermal flux density is below 50 cal/cm$^2$, sec. In addition to the nuclear radiation, the low-yield, close-in region has the problem of very small areas with desirable ranges of thermal fluence and thermal flux density. The level changes rapidly with distance.

At the high end of the curve, the nuclear radiation disappears, the blast pressure disappears, and the distances are sufficiently large that, in theory, useful areas on the ground can be subjected to effective levels of thermal flux density at acceptable levels of thermal fluence.

For example, 1000 cal/cm$^2$, sec can be obtained at 10 cal/cm$^2$ total about 112 km from 43 megatons. And this level will have fallen only 10 per cent 35 km from ground zero. If anthrax spores with an absorbtivity of 0.1 are to be heated to 500$^{\circ}$C, 15000 cal/cm$^2$, sec are required. If 10 cal/cm$^2$ fluence is to be maintained, extrapolation of the curves indicates 100 megatons at 165 km. It is highly unlikely that this extrapolation is valid.

The difficulty with the high and of the curve is that the data are only good to about 80 km, and very uncertain above.

If one is forced to an 80 km ceiling, to get 1000 cal/cm$^2$, sec, 160 cal/cm$^2$ will have to be accepted on the ground from a 4-gigaton burst. Such a fluence would be accepted very reluctantly!

If a more fragile organism, such as a virus, is to be attacked, or the particle size is 5 microns, 250 cal/cm$^2$, sec might suffice. This can be achieved by 25 megatons at 80 km, with only 10 cal/cm$^2$ on the ground, perhaps below a region of serious damage.

In summary, large-yield, high altitude nuclear bursts may be a way of defeating biological aerosols, especially of the more fragile organisms.

## 8.9 REFERENCES


1. Decker, H. M., F. J. Citek, J. B. Harstad, N. H. Gross, F. J. Piper, "Time Temperature Studies of Spore Penetration Through an Electric Air Sterilizer," (1954) App. Microbiol. 2 33.

2. Buttolph, "Practical Applications and Sources of Ultraviolet Energy," pp. 44 in "Radiation Biology," Vol. II, A. Hollaender Ed. McGraw-Hill (1957).

3. Van de Hulst, H. C., "Light Scattering by Small Particles," John Wiley and Son, Inc., New York (1957).

4. Plass, G. N., "Mie Scattering and Cross Sections for Absorbing Particles," (1966) Appl. Optics 5, 279.

5. Carslaw, H. C. and J. C. Jaeger, "Conduction Heat in Solids," 2nd Ed. Clarendon Press, Oxford (1959).

6. Jones, R. E., S. B. Martin, and R. H. Renner, "Nuclear Weapon Burst Parameters Governing Urban Fire Vulnerability," USNRDL-TR-67-118, May 1967, U. S. Naval Radiological Defense Laboratory, San Francisco, (Unclassified).

7. Glasstone, S., Ed. "The Effects of Nuclear Weapons," April 1962, USAEC (Unclassified).

## 9. WASHINGTON D. C. SUBWAY

G. A. Cristy

A succession of delays in the design of the Washington D. C. subway has postponed the scheduled evaluation of the subway as a part of a comprehensive blast shelter system. The preliminary conclusions reported last year[7] are still valid.

Progress has been made by the Washington Metropolitan Area Transportation Authority (WMATA) during the year. WMATA, a regional agency which took over the responsibilities of the National Capital Transportation Agency (NCTA) on October 1, 1967, has contracted for design of several portions of the subway. The following Architect-Engineering firms are working on designs by March 1, 1968:

1. Ammann and Whitney is designing the Judiciary Square Station, the 8th and G Street Station, and the subway between. This contract was let in August (1967) and is scheduled to be complete by July 1, 1968.

2. Kaiser Engineering is designing the DuPont Station and the subway from the station to Rock Creek. This contract was signed in October (1967) and is scheduled to be complete by September, 1968.

3. Tibbets-Abbott-McCarthy-Stratton is designing a 2550 feet section of twin tube subway extending from 15th and G Streets NW under Lafayette and Farragut Squares to Connecticut Avenue and K Street NW. This contract was let in November (1967) and will be complete by October, 1968.

4. Rummel, Klepper and Kahl consulting engineers in association with Mills, Petticord, and Mills (A-E) is designing the Farragut Square station and the 1800 feet section of tunnel connecting the station with the DuPont Circle station. This contract was signed in February 1968.

Much of the delay in starting the design was caused by the complexity of obtaining approvals for the subway stations architectural

design. The architectural consultant Harry Wiese proposed a number of designs before final approval was obtained from WMATA, the National Capital Planning Commission, and the Fine Arts Commission. The stations (shown in Figure 1) will be "brightly lighted lofty vaults of classic simplicity."[8] The structure will be a high arch varying somewhat in shape from 27-50 feet high and nearly 90 feet wide.

Another delay was caused by fears raised by the Smithsonian Institute that vibrations from the G Street tunnel would damage the new National Portrait Galleries Building (the newly restored Patent Office Building). This was resolved by modifying the location of the 8th and G Street station and the connecting subway, requiring extensive underpinning of adjacent buildings, and installing vibration dampeners between the subway and adjacent structures.

The WMATA has responsibility for planning and building a complete rapid transit for the Washington Metropolitan Area. This includes the suburbs in two counties of Virginia (Arlington and Fairfax) and two counties of Maryland (Prince Georges and Montgomery). In keeping with their planning responsibility WMATA has developed a proposal regional rapid transit plan[1] shown in Figure 2. This plan has been the subject of a number of hearings and public meetings in the District and in the suburban county governments this year for approval and financing.

This proposed plan expands the authorized 25 mile system to a 96 mile system. It would increase the route miles of subway from 12.4 to 42.9 and the number of subway stations from 19 to 49. The expected completion date for the presently authorized system is late in 1972. The additions required by the proposed plan would be scheduled to be complete before 1980. This plan, if approved would provide ready access to a subway entrance for a much larger percentage of the people within the metropolitan area. The increase in tunnel length would boost the estimated emergency capacity from one-half million[7] to 1.8 million. This is sufficient capacity for the 1990 projected population of the District plus a sizable

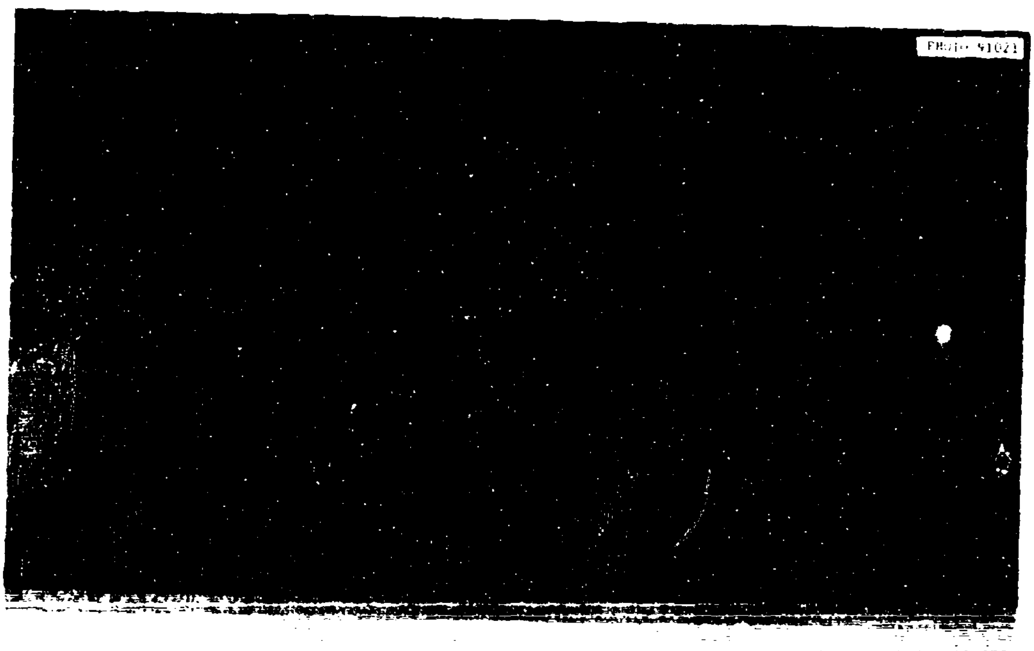

Fig. 9.1 Design for Washington's New Subway Stations

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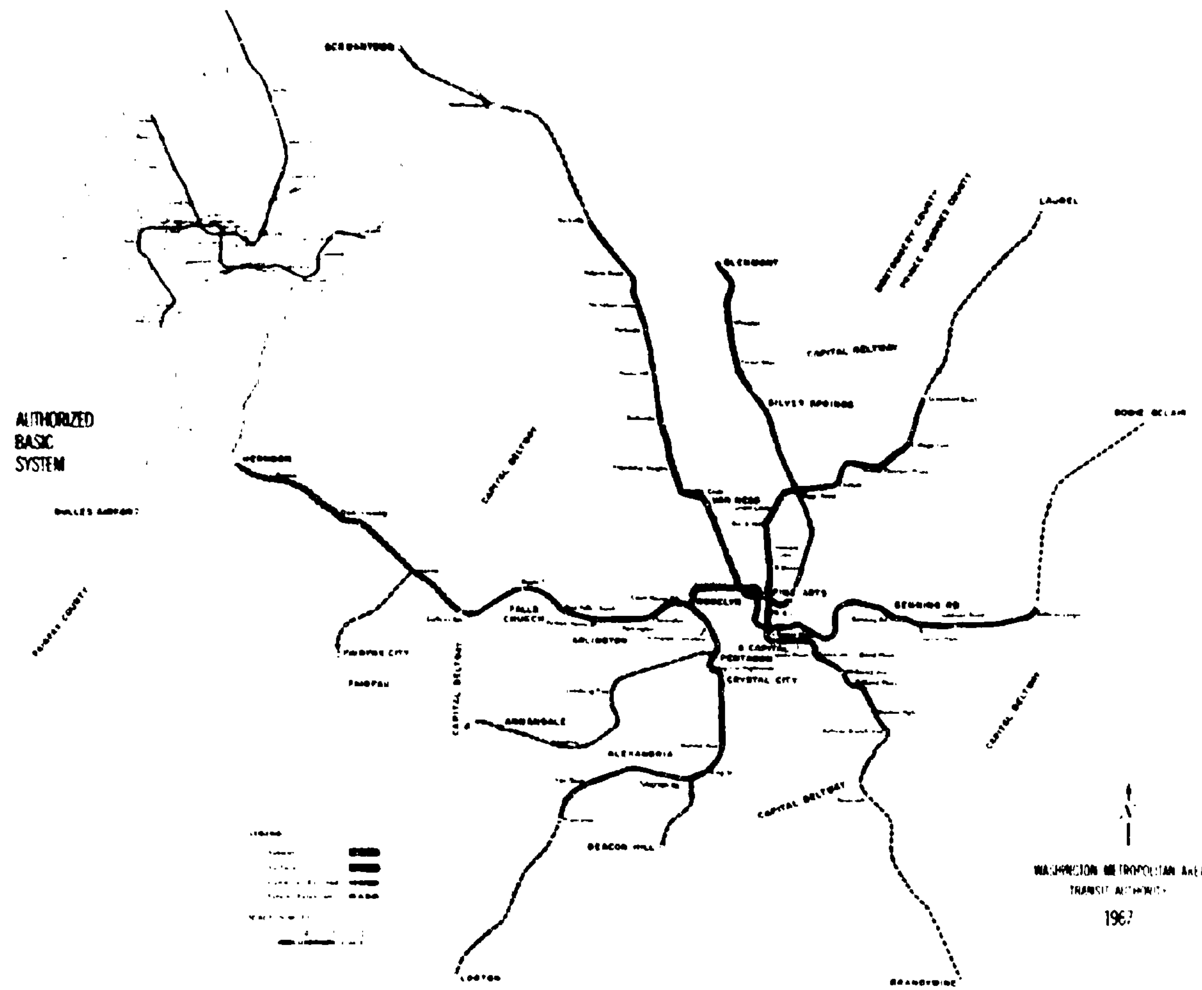


Fig. 9.2 Proposed Regional Rapid Rail Transit System

percentage of the residents of Montgomery County, Maryland, and Arlington County, Virginia. No subway is proposed in Fairfax County, Virginia, and less than two miles is planned for Prince Georges County, Maryland.

Although there have been delays in the progress of design of the presently approved system, the scheduled completion has not yet been very seriously delayed.

## 9.1 References


1. Proposed Regional Rapid Rail Transit Plan and Program Washington Metropolitan Area Transit Authority (WMATA) December 1967.

2. Technical Report No. 1 System Planning (WMATA) December 1967.

3. Technical Report Number 2 Capital Cost Analysis (WMATA) December 1967.

4. Technical Report Number 3 Traffic Forecast (WMATA) December 1967.

5. Technical Report Number 4 Operating Cost Analysis (WMATA) December 1967.

6. Technical Report Number 5 Financial Program (WMATA) December 1967.

7. "Washington D. C. Subway," Annual Progress Report Civil Defense Research Project March 1966-March 1967. ORNL-4184 Part I pp. 285-298.

8. "Subway Station Design Approved," The Washington Post, December 8, 1967, p. B-1.

# V. WEAPONS EFFECTS

## 10. REPORT OF SHOCK TUBE RESEARCH DURING THE PERIOD MARCH, 1967 - MARCH, 1968

L. Dresner and C. V. Chester

### 10.1 INTRODUCTION

This past year we have taken great strides forward in shock tube research, inproving both the mechanical aspects of our shock tube as well as our techniques of measurement. As a result of these improvements, we have been able to achieve a unified description of the attenuation of shocks in long tunnels, both bare and containing additional elements such as artificially roughened walls, baffles, and scaled models of human figures.

Figure 1 shows an overall view of our shock tube, which consists of pieces of four-inch ID pipe of various lengths. Each piece of pipe now rides on a steel cart, permitting easy rearrangement of the shock tube. The pieces of pipe are now joined to one another by Grayloc flanges (Gray Tool Co.) rather than the screw connections formerly used. The Grayloc flanges connect the various pieces of pipe in a very simple and convenient manner. These mechanical improvements have eliminated most of the problems of setting up and tearing down experiments.

In the past, the shock tube was driven by small amounts of condensed explosive (Detasheet-DuPont). Owing to the possibility of structural damage, we were limited to about 5 grams TNT equivalent. With this low yield, we had to evacuate the shock tube to rather low pressures (~10 mm Hg) in order to model the effects of megaton explosions on shelter tunnels. To avoid the inconvenience of pumping down, we abandoned condensed explosives in favor of exploding gases, which because they spread the explosion over a large volume, do not damage the shock tube. The gas mixture we use now is a 21% propane-79%

Fig. 10.1 An overall view of the four-inch shock tube.

oxygen mixture at a gauge pressure of 20 cm Hg. Before the explosion, the gas mixture fills a driver section at the upstream end of the pipe (the first two sections of pipe in Figure 1). A Dacron-reinforced polyethylene membrane confines the explosive mixture before the shot. The membrane is clamped in a special quick-release flange. The quick-release clamp is counterweighted, and when the membrane is being changed it rides smoothly out of the way. The gases are admitted to the dirver section through a valved connection in the end cap; another valved connection goes to a mercury manometer. The gases are detonated by a .22-caliber blank cartridge fired from a single-shot rifle mounted in the end cap.

Piezoelectric transducers manufactured by the Kistler Instrument Corporation are our measuring instruments. In the past, we used them to measure shock overpressures directly, but they were unsatisfactory in two regards. In the first place, they are sensitive to acceleration and therefore respond to the mechanical vibrations induced in the pipe wall by the passage of the shock wave. These vibrations produce a high-frequency background signal which makes it difficult to determine the shock over-pressure. Furthermore, even in cases in which this mechanical noise was not too bad, the reading of the transducer seemed to vary with the conditions of service: we have observed that simply removing a transducer from its mounting and returning it again changes its reading, sometimes by as much as 20%. Finally, when compared with overpressures determined from shock arrival times, directly measured overpressures appear to be 25% lower on the average. For all these reasons, we decided not to use the transducers to measure peak overpressures directly. Instead, we use them in pairs to time the flight of the shock wave over a four-inch length of pipe; the shock velocities determined in these measurements are then converted into shock overpressures using the Rankine-Hugoniot relations. Shock overpressures determined in this way show much less scatter than directly measured values, and we believe them to be more accurate.

Occasionally, we are interested not just in the shock overpressure

but in the entire pressure-time history at a point. Then we do use the transducers to measure the pressure directly. A slight technical difficulty arises here owing to the transfer of heat from the hot gases to the transducer. Heat transfer takes time, so the shock overpressure is unaffected, but after a few milliseconds the pressure indicated by the transducers drops below zero and occasionally goes negative by more than one atmosphere, an impossibility. Covering the transducers with two layers of 7-mil-thick plastic adhesive tape inhibits heat transfer and avoids this difficulty.

With these improvements, we have continued our studies of the attenuation of shock waves in long tunnels. We have concentrated our efforts on attenuating elements of three kinds: artificially roughened walls, baffles (orifice plates), and scale models of human figures. We have found from our experiments that the attenuation produced by these elements can be reliably correlated with the friction factor that would govern fully developed turbulent flow in the same pipe. This means that we are now in a position to predict the attenuation that would be produced by elements for which the friction factor for turbulent pipe flow is known.

## 10.2 RESULTS-BARE TUBE

To demonstrate the detonation of the gas mixture, we measured the detonation velocity in the driver section by timing the flight of the detonation front between pairs of transducers separated by a measured distance, usually of the order of 40 inches. According to measurements of Breton quoted by Lewis and von Elbe,[1] the detonation velocity of a 21%-79% propane-oxygen mixture is 2.50 km $sec^{-1}$ at atmospheric pressure, and is nearly independent of pressure. We carried out many experiments, detonating the gases with a spark, with .22-caliber blank cartridges, with #6 blasting caps, and with 5-gram explosive charges. Only the spark failed to detonate the gases reliably. The average detonation velocity measured in a large number of experiments employing the other detonators was 2.60 km $sec^{-1}$, ranging from a low of 2.50 to a high of 2.76 km $sec^{-1}$, a spread of about ± 5%.

Once we know the detonation velocity and have some idea about the energy released in the explosion, we can estimate the ratio of the specific heats of the burnt gas. In fact, if the explosion is strong, (i.e., if the detonation pressure is large compared with the initial gas pressure) these three quantities are simply related by the equation

$$\gamma = \left(1 + \frac{U^2}{2q}\right)^{1/2} \tag{1}$$

where U is the detonation velocity, q is the energy released in the explosion per gram of reactants, and $\gamma$ is the ratio of the specific heats of the burnt gas. Taking $U = 2.5$ km $\sec^{-1}$ and $q = 1.83$ kilocal $g^{-1}$ (corresponding to the stoichiometric combustion of propane and oxygen to carbon monoxide and water vapor), we find $\gamma = 1.19$.

Knowing $\gamma$, we can calculate the shock overpressure as a function of shock position by the numerical method of von Neumann and Richtmyer.[2] In this calculation, the total explosive energy and the length of the driver section are parameters. The initial data are the pressure, density, and velocity distributions behind the detonation front at the instant it reaches the membrane. The wave diagram corresponding to this initial data (Figure 2) is that of a Chapman-Jouguet detonation followed by a rarefaction wave. Because the flow behind a Chapman-Jouguet detonation is sonic relative to the front, the leading edge of the rarefaction coincides with the detonation front. Behind the rarefaction is a region of stationary burned gas of uniform pressure and density. The detailed computation of the initial data is described in reference 3.

When the detonation front reaches the end of the driver section (point P), conditions change abruptly, combustion energy no longer being supplied to the gas. The burned gas in the region $x < L$ now acts as the driver gas of a shock tube, while the air in the region $x > L$ acts as the gas being driven. A shock, contact surface, and rarefaction wave emanate from point P exactly as they do in an

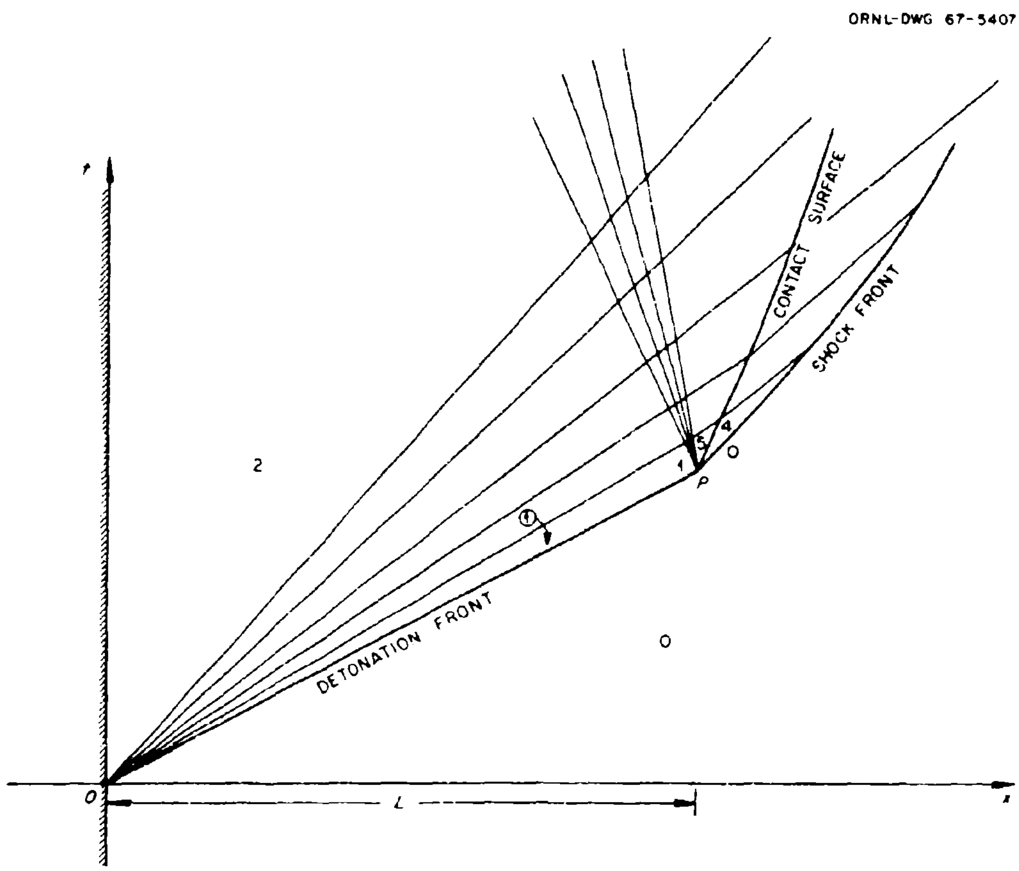


Fig. 10.2 Wave diagram for a shock tube driven by an exploding gas mixture.

ordinary shock tube. The contact surface separates the air that has passed through the shock front from the burned gas that has expanded through the rarefaction. Because of the presence of the rarefaction emanating from the origin O, the trajectories of the shock front and the contact surface cannot be calculated as simply as they are in the case of an ordinary shock tube (except in the immediate neighborhood of point P). However, they can be calculated numerically.

Figure 3 shows the result of two such calculations. Here, $\Delta p$ is the shock overpressure, L is the length of the driver section, X is the position of the shock front measured from the closed end of the driver section (and not from the membrane), E is the total energy of the explosion divided by the cross-sectional area of the shock tube, and $\gamma$ is the ratio of the specific heats of air. In the upper curve the ratio of the specific heats of the burned gas was taken to be the same as that of air, namely, 1.4. In the lower curve the ratio of the specific heats of the burned gas was taken to be 1.2. The difference is considerable, showing the importance of accounting for the change in the thermodynamic properties of the burned gas with temperature.

One very interesting feature of both of these curves is the plateau in the neighborhood of $X/L = 4$. This plateau is caused by the forward expansion of the region of stationary gas behind the rarefaction wave that follows the detonation front. This expansion catches up with the shock front in the vicinity of $X/L = 3$ and supports the shock front from about two driver lengths. This can be seen clearly from a time sequence of pressure, density, and velocity profiles given in reference 3.

Figure 4 shows shock overpressures measured by the flight-time method plotted against distance down the shock tube measured in driver lengths. The curve is the lower curve of Figure 3 normalized to a total explosive yield of 6 kilocal per foot of driver length. (In a four-inch tube, the stoichiometric combustion of propane and oxygen at a guage pressure of 20 cm Hg to carbon monoxide and water vapor would release 8.3 kilocal per foot of driver length.) The normalized curve

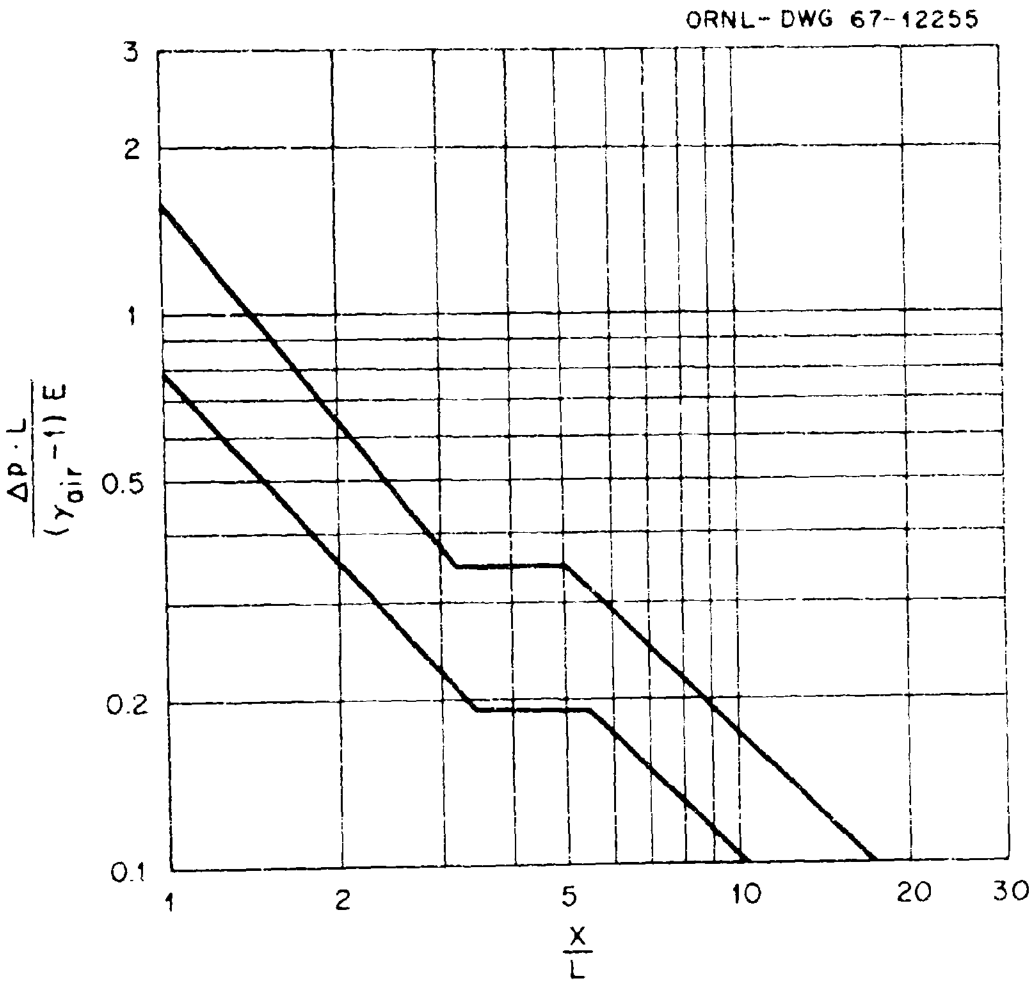


Fig. 10.3 Calculated shock overpressure as a function of distance down the shock tube for two values of the adiabatic exponent (ratio of specific heats) of the burned gas.

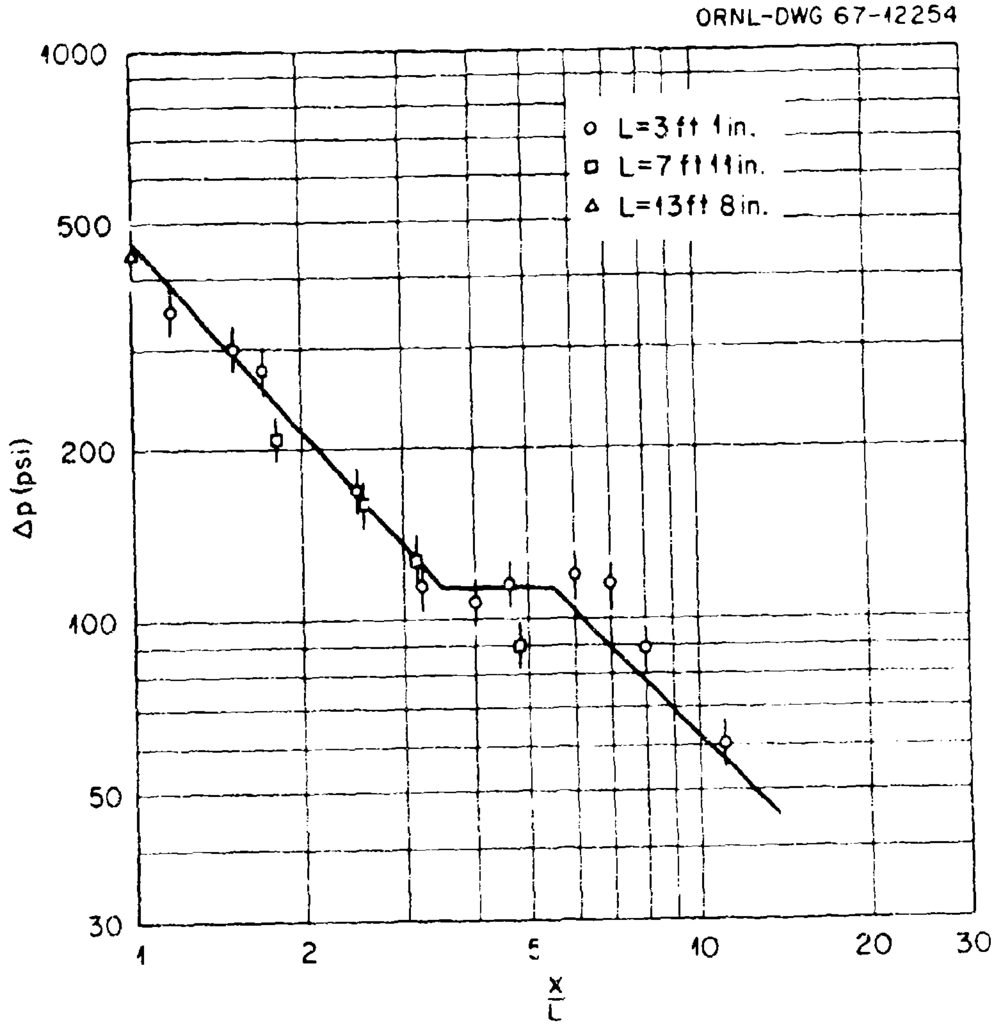


Fig. 10.4 Measured shock overpressure as a function of distance down the shock tube.

compares well with the measured points. Particularly gratifying is the experimental verification of the plateau, which is clearly evident, though somewhat wider than expected.

## 10.3 RESULTS - BAFFLED TUBES

The purpose of the experiments reported below was to test the effect of various elements inserted into the shock tube on the attenuation of shock waves. The elements were an artificially roughened wall, orifice plates, and scale models of human figures. The additional attenuation they produced can be related to the friction factor that would govern fully developed turbulent flow in the same pipe with the following formula

$$C = \exp(-0.30 f \Delta X / D) \qquad (2)$$

where

- $C$ is the factor by which the overpressure at the point of interest is reduced compared to what it would be at the same point in the bare tube,
- $f$ is the Fanning friction factor that would apply to the baffled section of pipe, i.e., the section of pipe containing the attenuating elements,
- $\Delta X$ is the distance from the beginning of the baffled section to the point of interest, and
- $D$ is the pipe diameter.

Equation (2) is based on the tacit assumption that the friction factor f is constant. In the pipes with artificially roughened walls or the pipes containing orifice plates described below, the friction factor becomes constant for Reynolds numbers greater than about $3 \times 10^4$. The Reynolds number of the flow behind a 100-psi shock in a four-inch pipe is about $6 \times 10^6$; for a 10-psi shock, it is about $1 \times 10^6$. However, as we shall see later, the friction factor of the scale models of the human figures may not be constant in the range of Reynolds numbers covered in our experiments.

Figure 5 shows overpressures measured in a section of pipe containing orifice plates with a 3-1/8-inch I.D. Three different spacings were used between the orifice plates, namely, 4", 8", and 12". The length L of the driver section was 37" in these experiments; the first orifice plate was located at 9'8". The pairs of transducers were symmetrically placed around the points at 12'0", 14'11", 17'11", and 21'0", with no orifice plates between the members of a pair.

The orifice plates used above have an area blockage of 39%. F. Arredi[4] has published measurements of the Fanning friction factor f for orifice plates with a 36% area blockage which cover fully the range of separation of one to three diameters. According to data of H. Mobius[5], the friction factor varies roughly as the square of the area blockage at constant spacing, so that Arredi's values need to be increased by a factor of about 1.17 to apply to our orifice plates. Correcting Arredi's data, we find f = 0.21, 0.15, and 0.12, respectively, according as the orifice plates are spaced 1, 2, or 3 diameters apart. Shown also in Figure 5, are curves referring to those values of f which were obtained by applying the correction calculated from Equation (2) to the curve given in Figure 4. Agreement with the experiments is good.

In order to test the validity of the correlation (1) over a wide range of friction factors, we performed an experiment in which the friction factor was reduced by approximately one order of magnitude. In this case, the wall of the shock tube was artificially roughened by cutting a V-thread in it with an apex angle of $60^\circ$ and a pitch of 0.125". Thus the depth-to-pitch ratio is 0.866 and the depth-to-diameter ratio in a four-inch pipe is 0.0271. Schiller[6] has reported values of f for various "Löwenherz" threads (metric threads with a depth-to-pitch ratio of 0.75 and flats at top and bottom equal to one-eigth of the pitch). In one of his experiments, the depth-to-diameter ratio was 0.0286; the corresponding value of f was about 0.013. Shown in Figure 6 are experimental values of the overpressure. The driver length was again 37"; the threaded section began at 9'8".

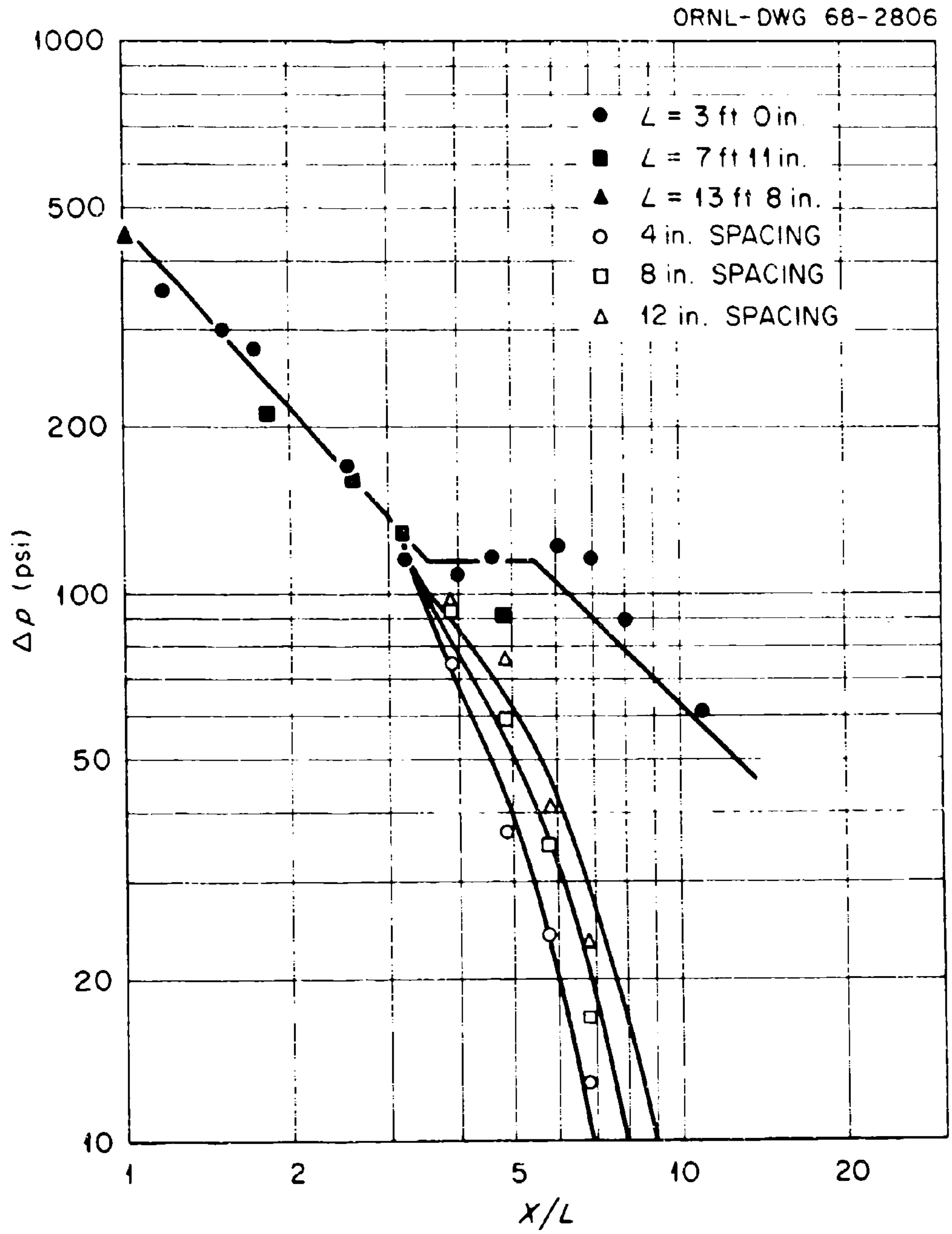


Fig. 10.5 Shock overpressure in a tube containing orifice plates.

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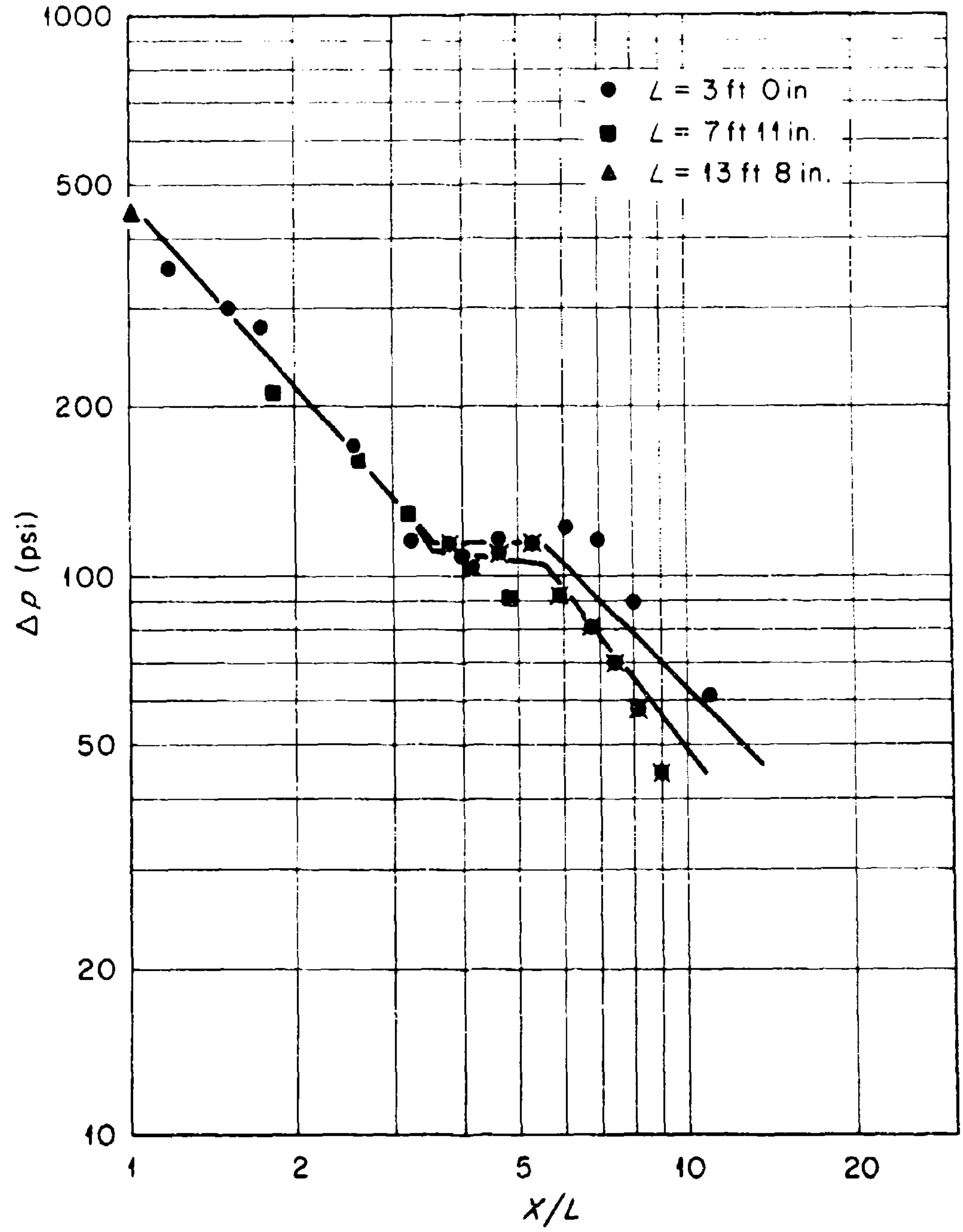


Fig. 10.6 Shock overpressure in a tube with a threaded wall.

Shown also is a curve calculated in the same way as before and based on f = 0.013. Agreement is again good.

The last set of experiments was conducted using scale models of human beings in the shock tube. The models were aluminum dowels 1/2" in diameter and 2-1/2" long; in an eight-foot-diameter tunnel these dowels would correspond to a five-foot-tall figure with a mean diameter of one foot. The dowels were screwed permanently into a base plate in a triangular array shown in Figure 7. Five different patterns were used, all of which are also shown in Figure 7. The full-density pattern contains 8 dowels per diameter, corresponding to a shelter packing of approximately 5,000 people per mile of eight-foot-diameter tunnel. Of the remaining four patterns, two correspond to two-thirds density, and two to one-third density.

Shown in Figures 8 a-e are overpressures measured at various positions down the tube for these five patterns. In all cases, the dowel-filled section of pipe began at 10'0". Three curves are drawn in each figure, but before we consider them, we can draw some interesting conclusions by comparing the different sets of points. The two sets of points corresponding to two-thirds density agree with one another fairly well, although there appear to be some differences in fine structure. The set of points corresponding to full density also agrees with these two, in contradiction to the expectation that it would be corrected by a factor C [See Equation (2)] equal to the three-halves power of that applying to two-thirds density. Thus it appears that the local flow perturbations introduced by the presence of the pegs may interfere with one another (either constructively or destructively), thus affecting the friction factor. Such behavior has been observed by Schlichting in turbulent pipe flow.[7] Comparison Figures 8d and 8e both referring to one-third density, shows further effects of such flow interference.

The same three curves are shown in each of Figures 8 a-e. These curves have been calculated using Equation (2) with friction factors arrived at in the following way. The Reynolds number of the flow behind a 100-psi shock moving into air at STP is about $7.7 \times 10^5$ when

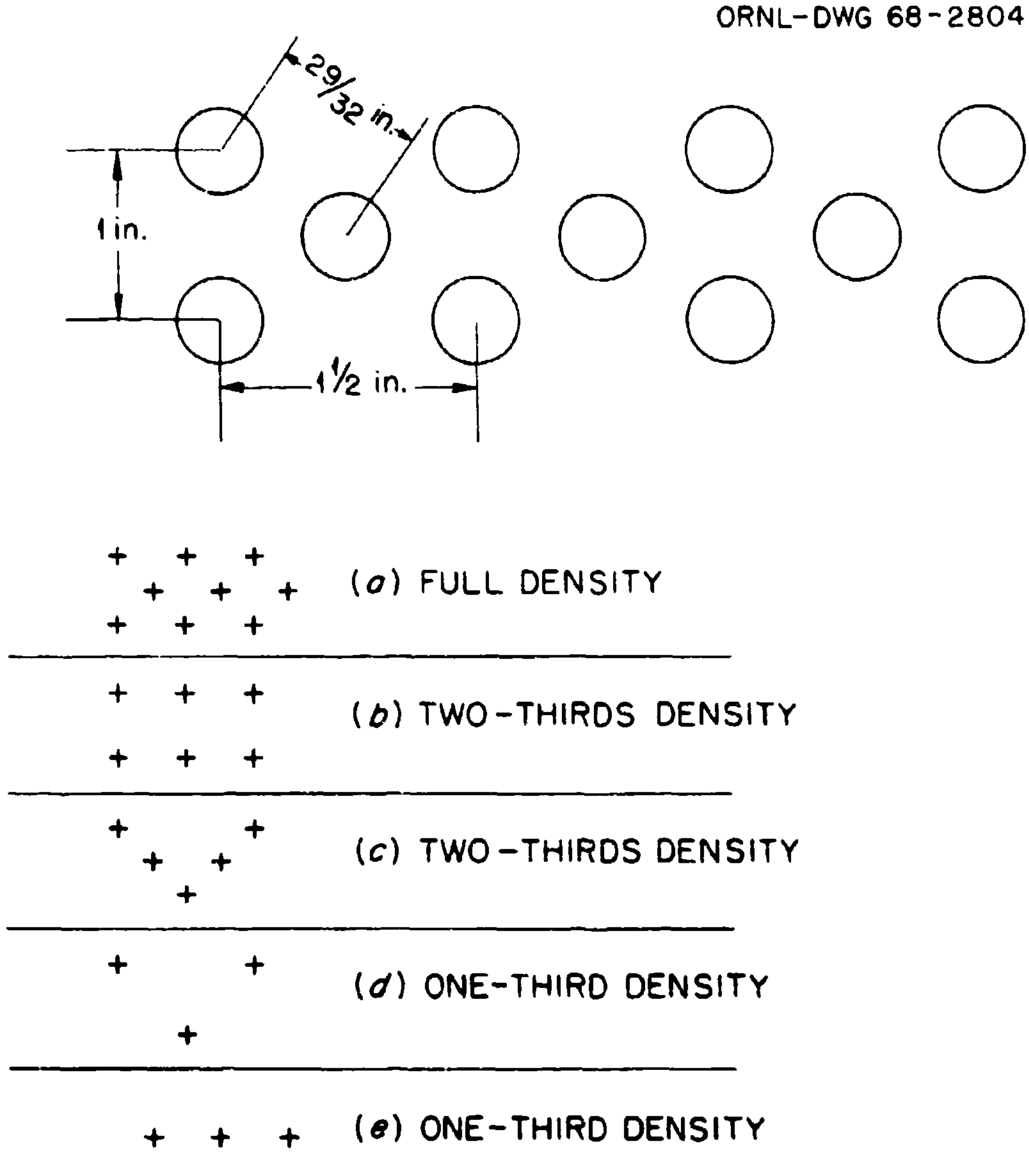


Fig. 10.7 Packing patterns for aluminum dowels.

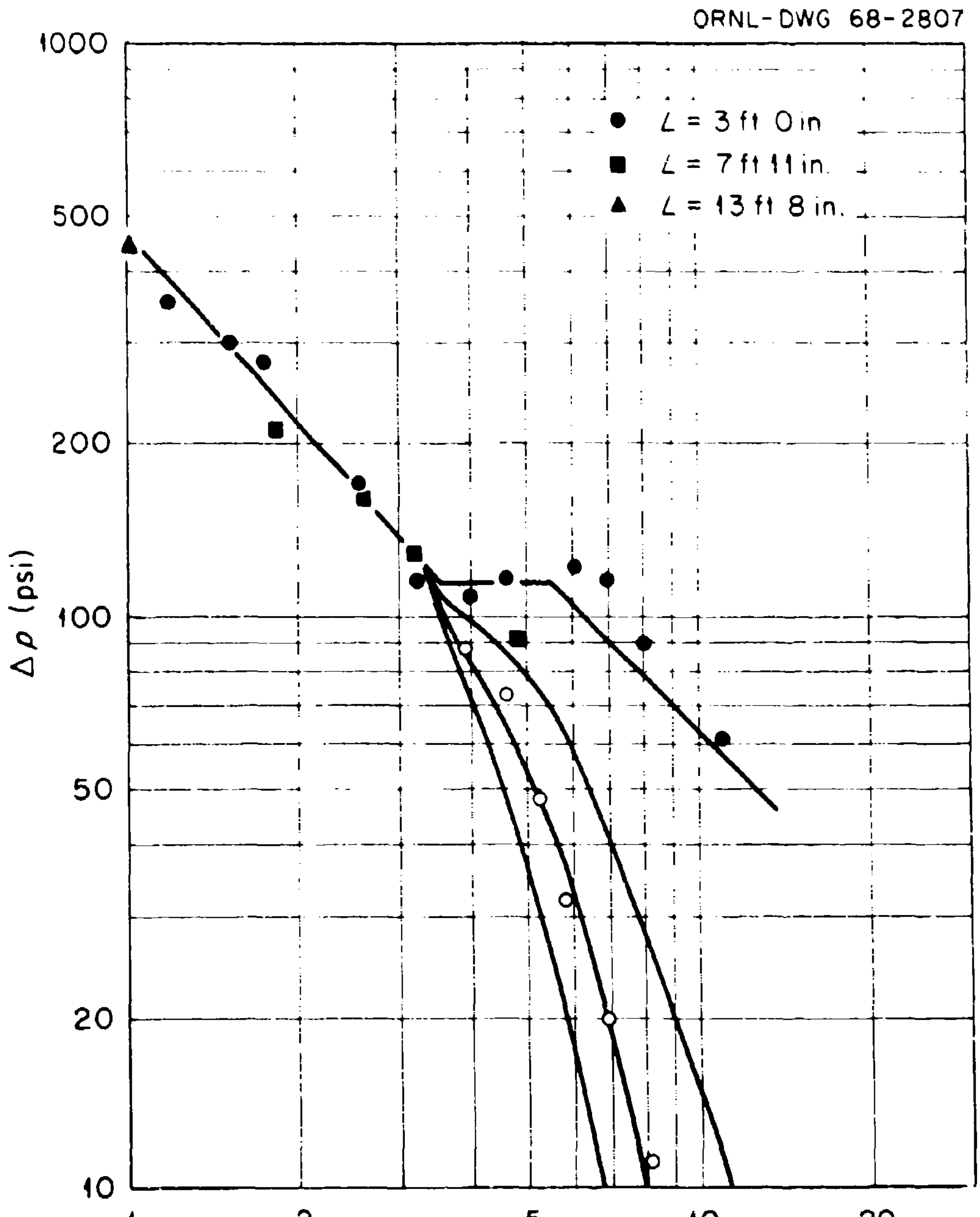


Fig. 10.8a Shock overpressure in a tube containing aluminum dowels - packing pattern (a).

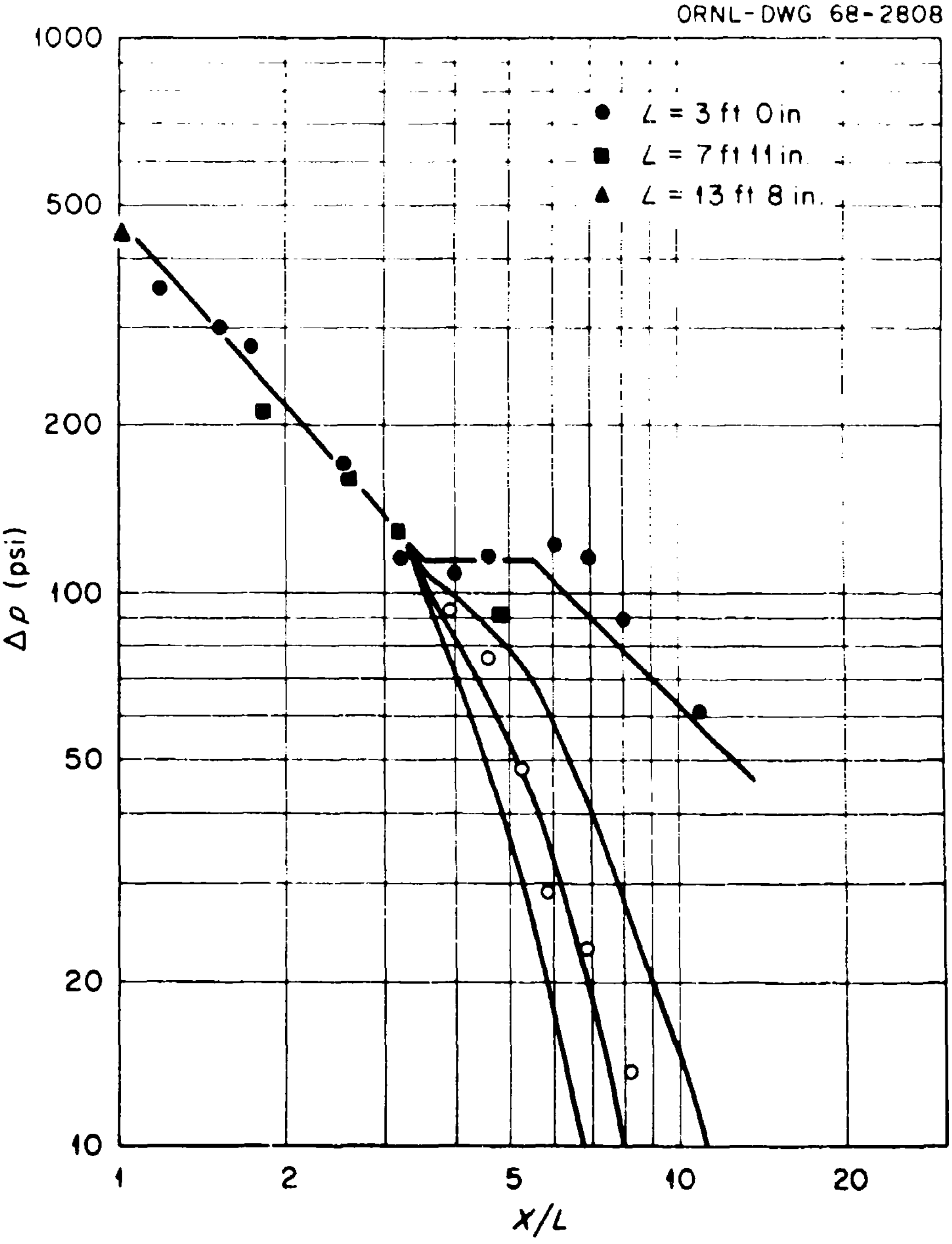


Fig. 10.8b Shock overpressure in a tube containing aluminum dowels - packing pattern (b).

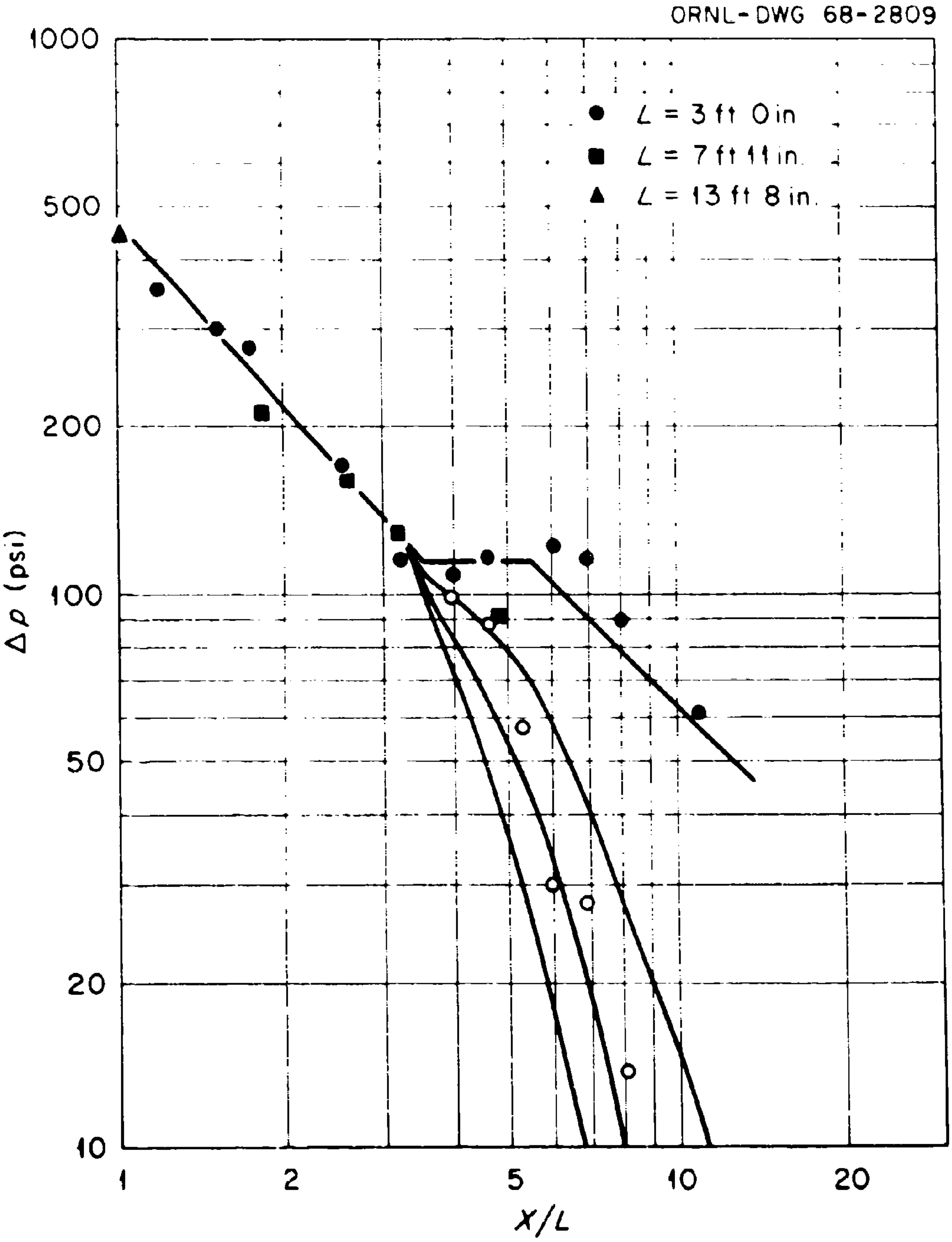


Fig. 10.8c Shock overpressure in a tube containing aluminum dowels - packing pattern (c).

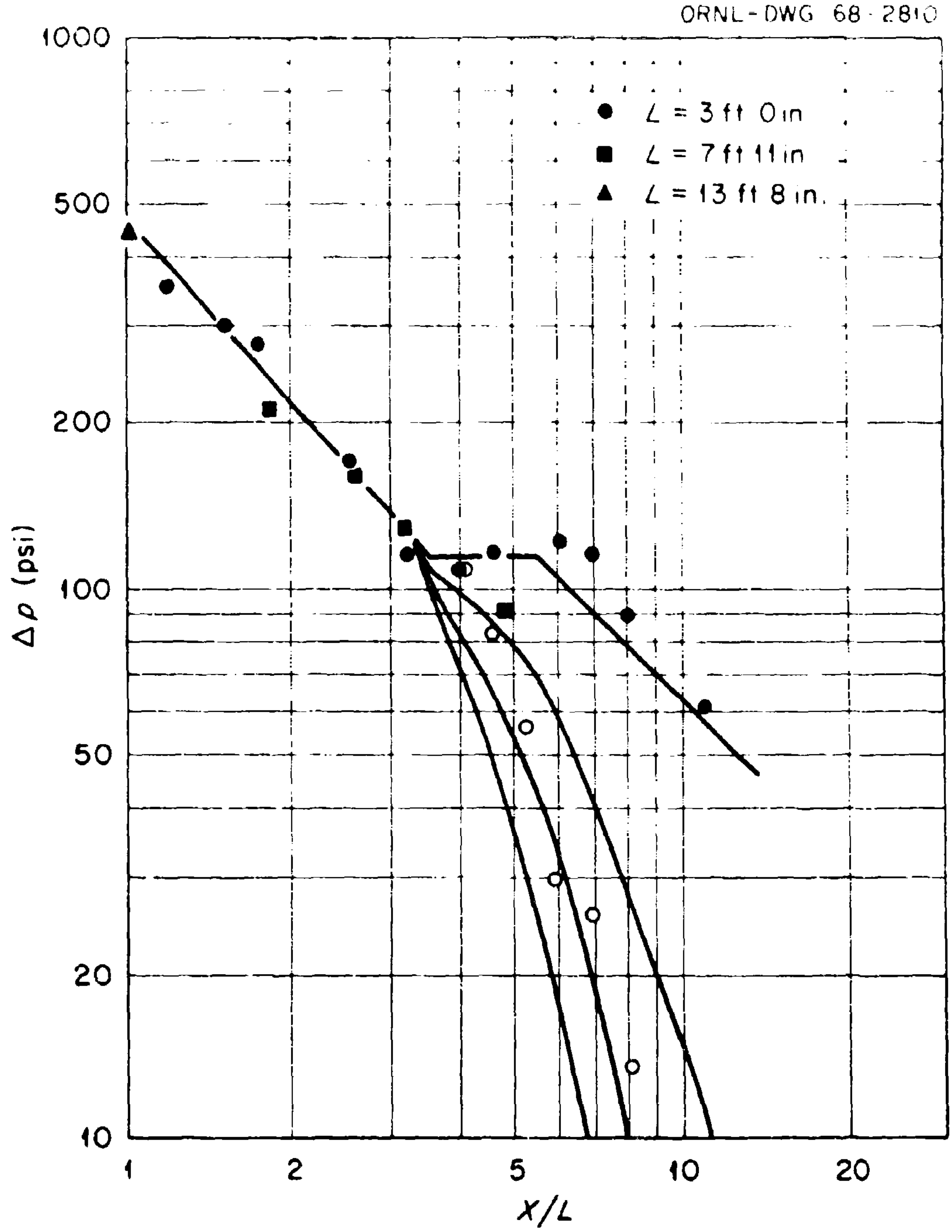


Fig. 10.8d Shock overpressure in a tube containing aluminum dowels - packing pattern (d).

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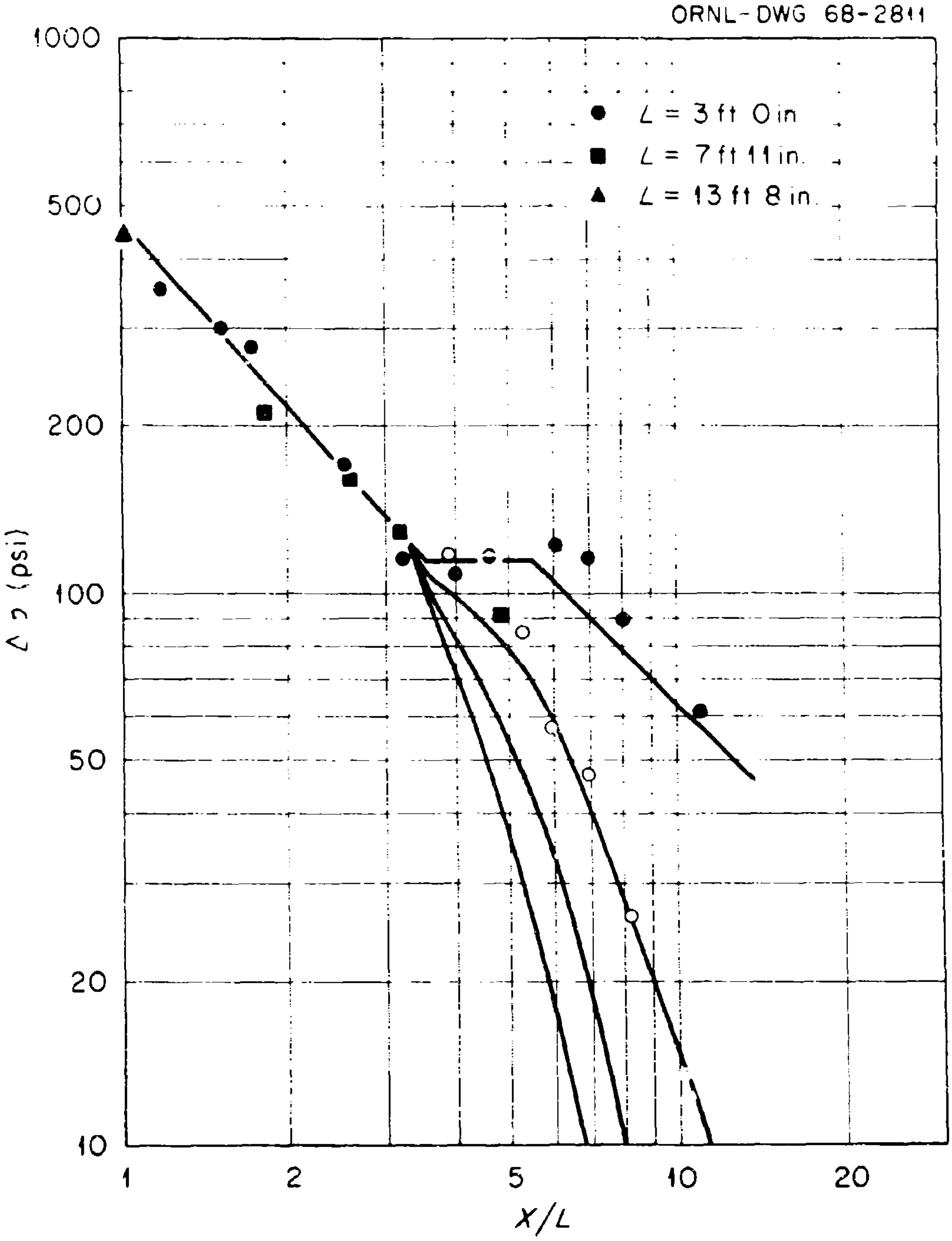


Fig. 10.8e Shock overpressure in a tube containing aluminum dowels - packing pattern (e).

computed with the half-inch diameter of the aluminum dowels; the Reynolds number corresponding to a 10-psi shock is about $1.3 \times 10^5$. This is the range of Reynolds numbers covered in the experiments reported by Schlichting.[8] In this range, the skin friction coefficient $c_f$ of cylinders falls from a plateau of about 1.15 to a valley of about 0.3. The three curves shown in Figure 8 are based on values of the skin friction coefficient of 1.15, two-thirds this value (0.77), and one-third this value (0.38). Since the skin friction coefficient is referred to the projected area of the cylinders rather than the wetted surface of the pipe, the value of f to be used in Equation (2) is related to $c_f$ by the equation

$$\frac{f}{c_f} = \frac{d\ h\ N}{\pi D} \qquad (3)$$

where

- d is the diameter of the cylinders,
- h is their height,
- N is their density (cylinders per unit length of pipe), and
- D is the diameter of the pipe.

The three values of f are 0.23, 0.15, and 0.77 respectively. The three curves can also be used to estimate the theoretical difference to be expected due to the different densities of packing used. The estimates of attenuation based on Equation (2) roughly consistent with the measurements, but without better values of the friction factor no true test of the theory is possible.

## 10.4 CONCLUSIONS

The experiments reported here already supply valuable information on situations of practical interest at a scale of 24:1. In addition, they lend strong support to Equation (2), from which useful engineering estimates of shock attenuation can be made. To further check Equation (2), experiments are planned in which a configuration of

1/8-inch dowels with a precisely known friction factor is used. Finally, the experiments will be extended to greater attenuations to determine the limits of validity of Equation (2).

## 10.5 REFERENCES


1. B. Lewis and G. von Elbe, "Combustion, Flames and Explosions of Gases," Academic Press, New York, 1961, p. 531.

2. J. von Neumann and R. D. Richtmyer, Journal of Applied Physics 21 232 (1950).

3. L. Dresner, "The Variation of Shock Overpressure with Distance in an Explosively Driven Shock Tube," ORNL-TM-1966, September 12, 1967.

4. F. Arredi, Ricerche di Ing. 8 264 (1934), results quoted in reference 6.

5. H. Möbius, Physikalische Zeitschrift 41 202 (1940).

6. L. Schiller, Zeitschrift für angewandte Methematik und Mechanik 3 2 (1923).

7. H. Schlichting, "Grenzschicht-Theorie," G. Braun, Karlsruhe, 1951, p. 386.

8. Ibid., p. 15.

# 11. THE PEAK OVERPRESSURE AT THE FOOT OF A VERTICAL WALL FACING AN AIR BLAST

Lawrence Dresner

## 11.1 INTRODUCTION

The peak overpressure at the foot of a vertical wall facing an air blast is higher than the peak overpressure at the same point when the wall is absent. Multiple reflections of the incident shock front in the right angle between the wall and the ground cause the increase. Generally speaking, multiple reflection of shock waves leads to complicated flow fields that are impossible to analyze, but fortunately, in the problem at hand, practical results can be obtained by studying a few simple, analyzable flow fields.

## 11.2 ANALYSIS

Figure 1 shows the situation we shall study. The dimensions of the wall have purposely been exaggerated in comparison with the burst heights and ranges of nuclear explosions.

When a shock wave strikes a reflecting surface, two different kinds of reflection can occur: regular reflection and Mach reflection. Which one actually occurs depends on the shock strength and the angle of incidence. It appears, then, that we have to analyze four different situations according to whether regular or Mach reflection occurs at the ground and at the wall. However, in the Mach region the incident shock will not strike the wall at all if the Mach stem is higher than the wall, as it will be except in a small region near the point where Mach reflection begins. Thus, we shall consider only one situation in the Mach region, that shown in Figure 2-1.

The reflection of the Mach stem at the wall is the same as the reflection of any shock wave normally incident on a plane wall. Hence we can find the peak pressure at the base of the wall, and indeed over

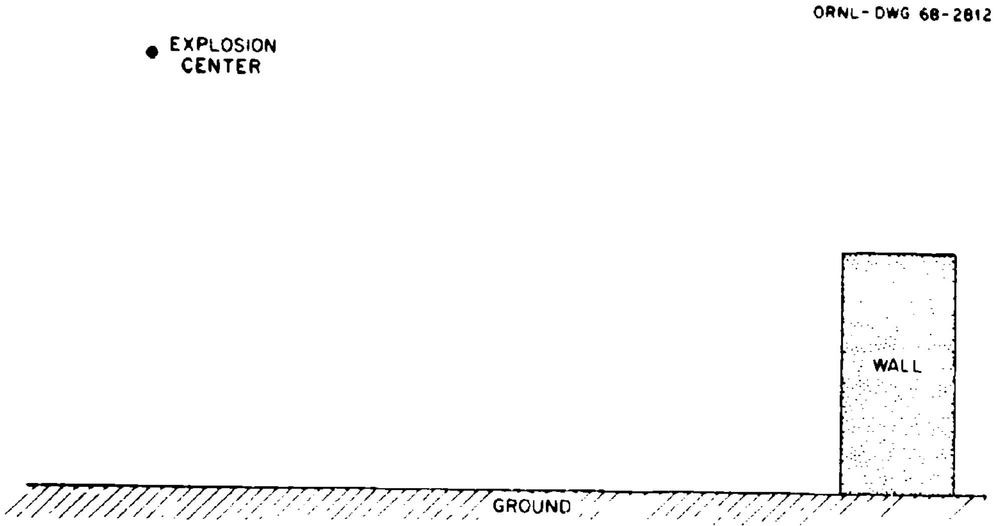


Fig. 11.1 Vertical Wall Facing Air Blast

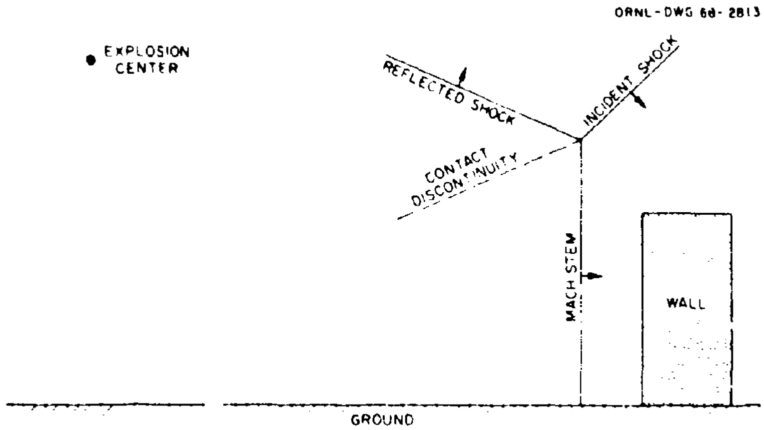


Fig. 11.2-1 Mach Reflection on Ground

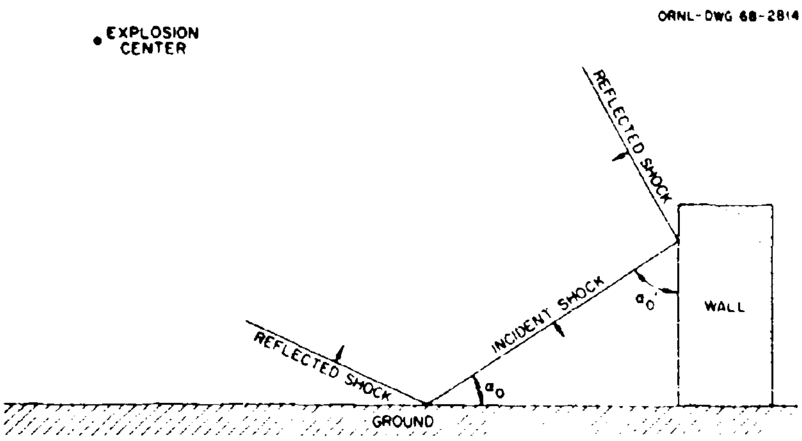


Fig. 11.2-2 Two Regular Reflections

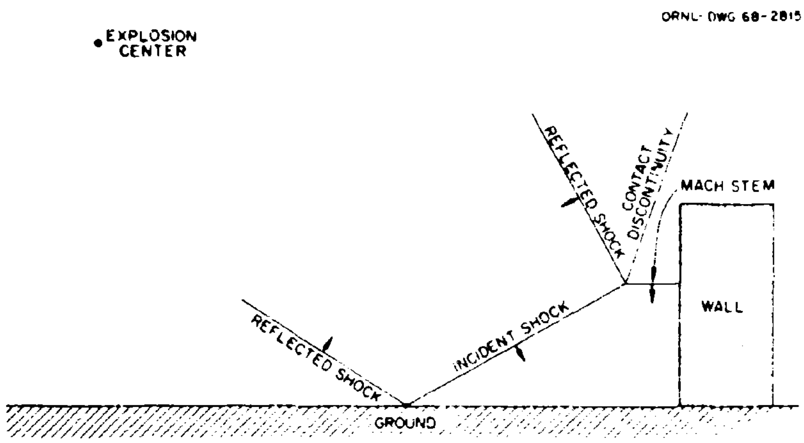


Fig. 11.2-3 Regular Reflection on Ground - Mach Reflection on Wall

its entire face, by combining the known solutions of the problems of oblique and normal shock reflection.

When the reflection on the ground is regular, two situations, shown in Figures 2-2 and 2-3, are possible. That shown in Figure 2-2 is of lesser importance, being possible only when the incident shock has a peak overpressure less than 9.8 psi. This can easily be shown by considering Figure 54 of Section 125 of reference 1. This figure, reproduced here as Figure 3, shows the angles of incidence $\alpha_0$ and the pressure ratio $p_0/p_1 = \xi$ of the incident shock for which regular reflection is or is not possible. Here $p_0$ is the pressure of the undisturbed air, and $p_1$ the pressure (not overpressure) of the air behind the shock front. The curve marked E and the line $\alpha_0 = 45^\circ$ intersect at $p_0/p_1 = 0.60$. When $p_0/p_1 \leq 0.60$, if $\alpha_0$ lies in the domain where regular reflection is possible, $\alpha_0' = 90^\circ - \alpha_0$, the angle of incidence on the wall, must lie in the domain where no regular reflection exists, which is what we wished to prove. Finally, $p_0/p_1 \leq 0.60$ implies $\Delta p_1 \geq$ 9.8 psi.

The conclusion that the configuration shown in Figure 2-2 can only occur for $\Delta p_1 \leq 9.8$ psi is based on the impossibility of satisfying the conservation relations that must hold across shock fronts when $\Delta p_1 > 9.8$ psi. The experimental evidence, as summarized by Courant and Friedrichs,[2] seems to indicate that while the configuration is possible for weak enough shocks, it does not actually occur. According to Courant and Friedrichs, if we keep the strength of the incident shock wave fixed and change the angle of incidence gradually from $0^\circ$ to $90^\circ$, the reflection is regular until stationary Mach reflection is reached; from then on Mach reflection occurs. Since the angle at which stationary Mach reflection appears is always less than $45^\circ$ (See Figure 66 of Reference 1), the configuration of Figure 2-2 will not occur. Thus the only configuration of shocks possible when the incident shock undergoes regular reflection on the ground is that shown in Figure 2-3. Normal reflection of the downward-moving Mach stem on the ground produces the peak overpressure, which can be calculated exactly as for the configuration of Figure 2-1.

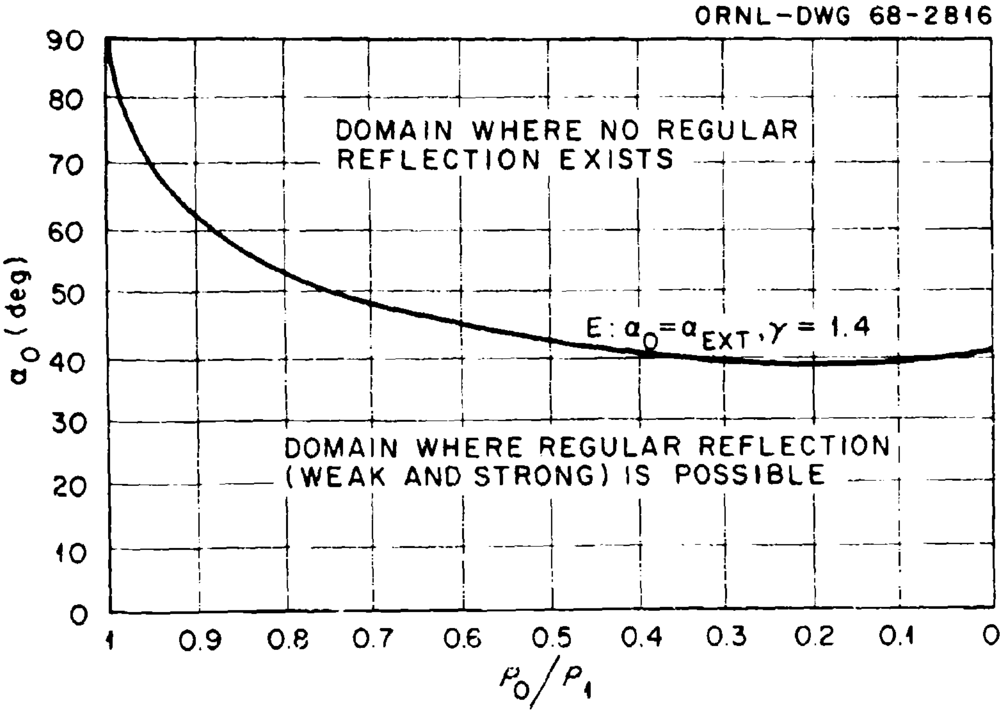


Fig. 11.3 The domain in which regular reflection is possible. $\alpha_o$ is the angle between the incident shock front and the reflecting surface, $p_o$ is the pressure of the ambient air and $p_1$ is the pressure of the air behind the incident shock.

Figure 4 shows the peak overpressure at the foot of the wall as a function of angle of incidence for five incident overpressures between 44.1 and 195.3 psi. The left-hand branch of each curve corresponds to the configuration of Figure 2-3; the right-hand branch to that of Figure 2-1. The discontinuity occurs at the angle of stationary Mach reflection. The calculations were done with the aid of published graphs of the so-called "magnification factor" (the ratio of the pressure behind the reflected shock to the pressure behind the incident shock) as a function of angle of incidence for various strengths of the incident shock.[3] I supplemented these published graphs with additional graphs of my own.

The implications of Figure 4 are dramatic. Consider, for example, a blast door mounted <u>flat on the ground</u> and exposed to a 44.1-psi shock at an angle of incidence of $40^{\circ}$. The reflected overpressure is then 137 psi. According to Figure 4, the same door mounted vertically would have to withstand a peak overpressure of 770 psi, more than 5.6 times as great as in the horizontal position. This example has been chosen to be dramatic, but the reflected overpressure on a horizontal blast door is always less than or equal to that on a vertical blast door (the two becoming equal at ground zero).

## 11.3 EXPERIMENTS

In order to check the theory outlined above, I performed some experiments, described below, in the four-inch explosively driven shock tube.[4] A cylinder with a right angle cut out of it (Figure 5) was mounted in the shock tube with the two faces of the right angle inclined $30^{\circ}$ and $60^{\circ}$, respectively, to the axis of the shock tube. A schematic diagram of the experimental setup is shown in Figure 6. Two transducers were mounted four inches apart just in front of the cylinder; by timing the flight of the shock front between them, the shock velocity could be obtained. The overpressure of the incident shock could then be calculated from the shock velocity. A single transducer located in the apex of the right angle with its face parallel to the shorter leg measured

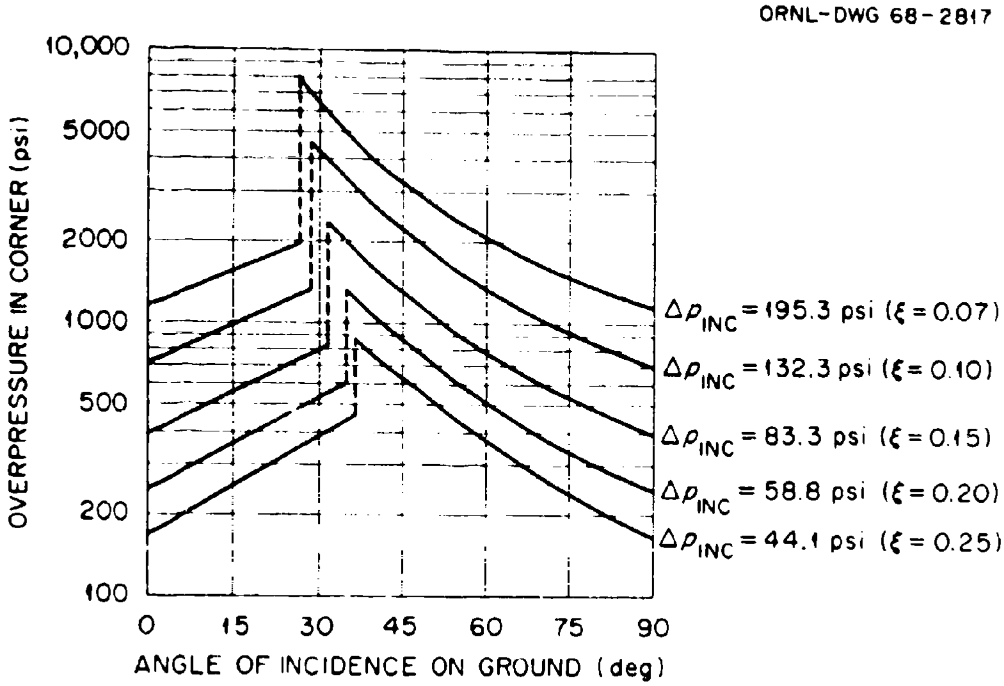


Fig. 11.4 The peak overpressure in the reentrant right angle between a vertical wall and the ground as a function of angle of incidence on the ground for several incident overpressures.

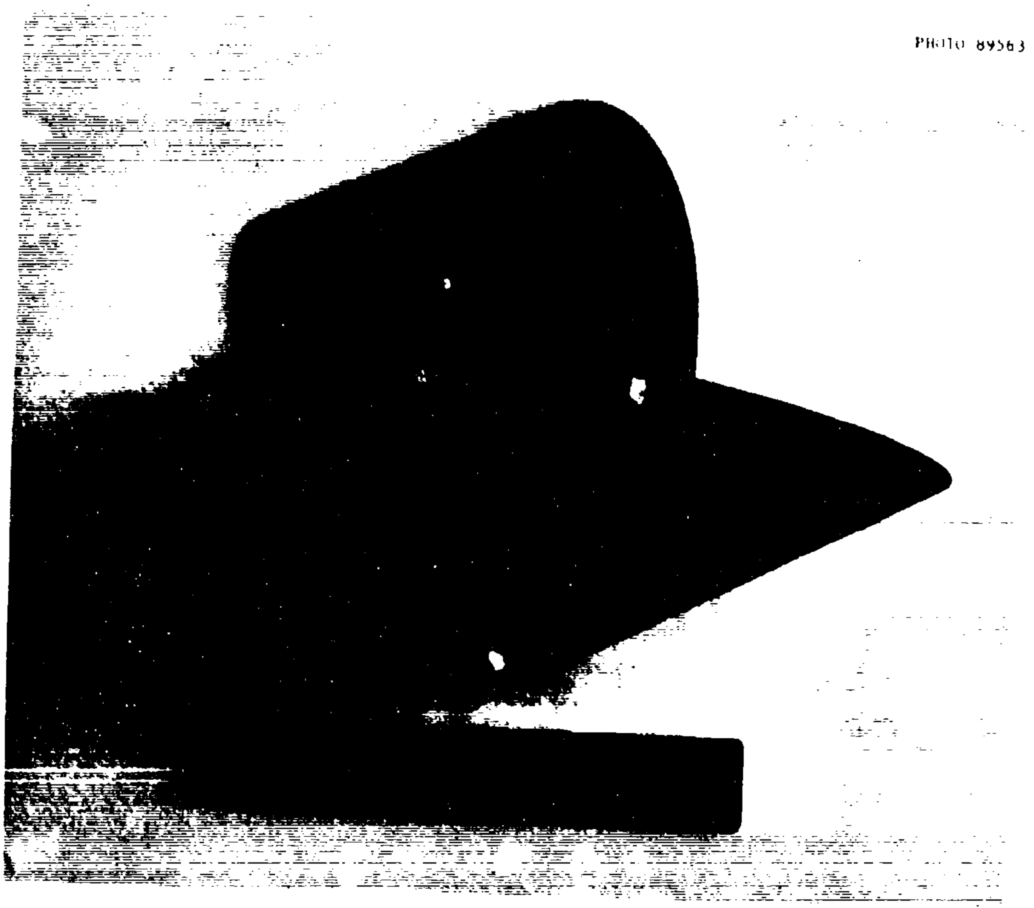


Fig. 11.5 Model for $30^\circ/60^\circ$ Reflection Experiments

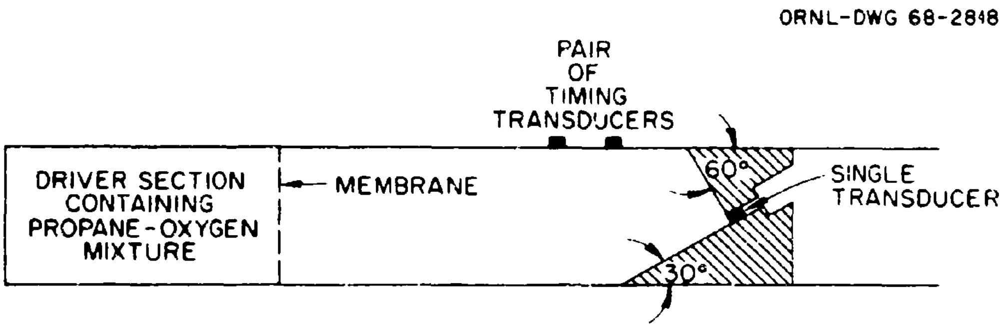


Fig. 11.6 A schematic diagram of the experimental setup.

the reflected pressure. The incident pressure was varied by varying the distance of the cylinder from the driver end of the shock tube.

For incident overpressures less than 105 psi, the incident shock front suffers Mach reflection on the longer leg of the right angle and regular reflection on the shorter leg, corresponding exactly to the situation shown in Figure 2-3. For incident overpressures greater than 105 psi, Mach reflection occurs on both legs of the right angle (Figure 7). When the incident overpressure is only slightly greater than 105 psi, the Mach reflection on the shorter leg is close to stationary reflection, which is to say, the velocity of growth of the Mach stem is small compared to the velocity at which it moves along the shorter leg. This means that the instant the two Mach stems first touch, that moving along the long leg will be much longer than that moving along the short leg. For example, when the incident overpressure is 132.3 psi ($\xi$ = 0.1), the two Mach stems are 0.58" and 0.0061" long, respectively, at contact, a difference of almost a factor of 100. Even when the incident overpressure is as high as 475.3 psi ($\xi$ = 0.03), the two Mach stems differ by more than a factor of 20 in size, the larger one being about 0.56" long and the smaller 0.027" long. Since the velocities of propagation of the two Mach stems are comparable, it is clear that the foot of the Mach stem traveling along the long leg of the right angle will collide normally with the short leg, free from any perturbation caused by the Mach stem traveling along the short leg. Hence, the peak overpressure should again be due to the normal reflection of the Mach stem traveling along the long leg.

Figure 8 shows the reflected overpressure at the vertex of the right angle as a function of the incident overpressure for the $30^\circ$-$60^\circ$ case. The curve has been calculated by assuming the Mach stem traveling along the long leg to be normally reflected from the short leg. The points are experimental. The agreement is very good for incident overpressures greater than about 100 psi, whereas for lower pressures the theory gives a slight overestimate. On the whole, the comparison supports the contention that the simple theory outlined above is substantially

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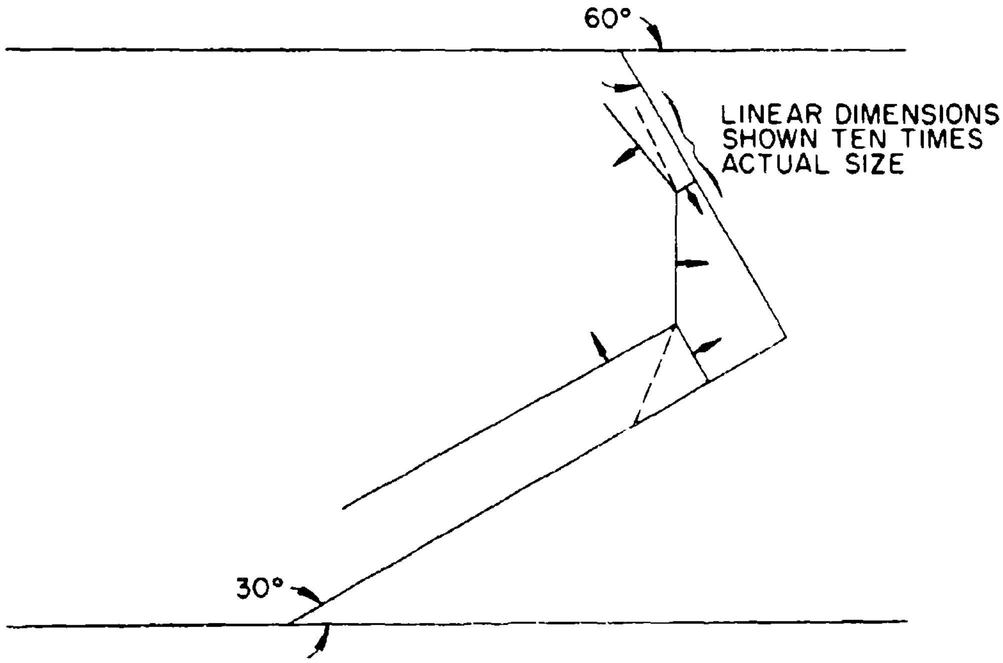


Fig. 11.7 Sketch showing the configuration of shocks when there is Mach reflection on both faces of the 30°/60° wedge. The angles correspond to an incident shock overpressure of 475 psi; the Mach stem moving along the shorter leg of the right angle has been shown ten times its actual size.

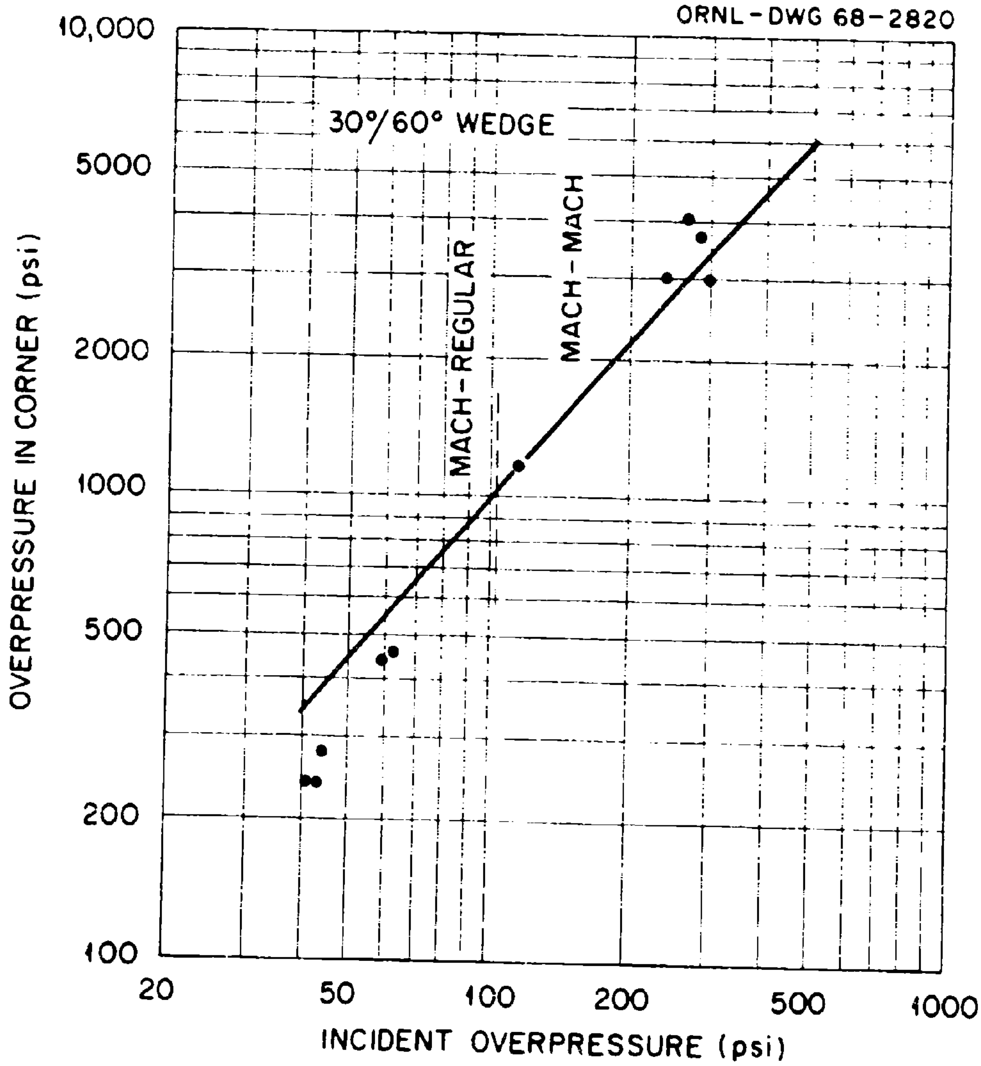


Fig. 11.8 The peak overpressure in the reentrant right angle of the 30°/60° wedge as a function of the incident overpressure.

correct. Of course, the Mach-Mach situations being considered here are excluded in the theory on which Figure 4 is based by the assumption that the Mach stem traveling along the ground is higher than the wall.

The key point in the above discussion of the Mach-Mach situations is the difference in the lengths of the two Mach stems. It is interesting to ask what would happen if the right angle were symmetrically oriented so that each of its legs made a $45^{\circ}$ angle with the axis of the shock tube. Since the angle of incidence on both legs is now $45^{\circ}$, the incident shock undergoes Mach reflection on both legs. Furthermore, both Mach stems have exactly the same size at all times owing to the symmetry of the situation. Hence the previous analysis cannot be used.

To aid in analyzing the $45^{\circ}$- $45^{\circ}$ case, we shall make use of the fact that the plane that bisects the right angle can be replaced by a rigid wall and only half of the right angle considered. Now as time passes, the Mach stem grows and eventually reaches the bisecting plane. It is incident on that plane that an angle of $45^{\circ}$, and undergoes another Mach reflection there. Of course, the reflected shock from the first Mach reflection also is reflected at this point and a rather complicated flow develops near this point. If this process continues indefinitely, it would appear that the reflected pressure in the vertex of the right angle becomes infinite, but it is impossible to be certain of this because of the complexity of the flow field.

Before abandoning analysis of the situation, however, we should examine the numerical values of the verious quantities involved. For definiteness, let us consider an incident overpressure of 83.3 psi ($\xi = 0.15$). The trajectory of the top of the first Mach stem is a straight line inclined only $3.1^{\circ}$ to the leg of the right angle. Hence, when the top finally reaches the bisector, the foot of the Mach stem is only 0.14" from the vertex, measured along the leg. The top of the second Mach stem is inclined only $3.8^{\circ}$ to the bisector; it reaches the leg at a point only 0.014" from the vertex, measured along the leg.

Let us now examine conditions on the last quarter of an inch of the leg before we reach the vertex. This is the region occupied by the face of the transducer. Except for a very small region right near the vertex, the transducer face sees only the passage of the first Mach stem and experiences at first only the pressure of the air behind it. Since the air behind the first Mach stem is moving into the right angle, it must eventually come to rest. Thus we expect that out of the small region of multiple reflection right near the vertex, the reflected shock will emerge, moving parallel to the leg, across which the shocked air behind the first Mach stem will come to rest. The pressure behind this reflected shock front will be just that due to the normal reflection of the first Mach stem. Because the transducer face is much larger than the tiny region of multiple reflection, this is the pressure it will record. A much smaller transducer would presumably record a much higher reflected pressure.

To test the above ideas, an experiment was performed with a $45^{\circ}$ - $45^{\circ}$ cylinder. The results, together with a curve calculated by assuming normal reflection of the first Mach stem, are shown in Figure 9. The agreement of theory and experiment is about as good as in Figure 8, again being better for higher incident overpressures than for lower.

## 11.4 CONCLUSIONS

Practical results for the pressure amplification in the right angle between two planes can be obtained by combining the known solutions of the problems of oblique and normal shock reflection. Figure 4 shows the peak overpressure at the foot of a vertical wall as a function of angle of incidence for several incident overpressures.

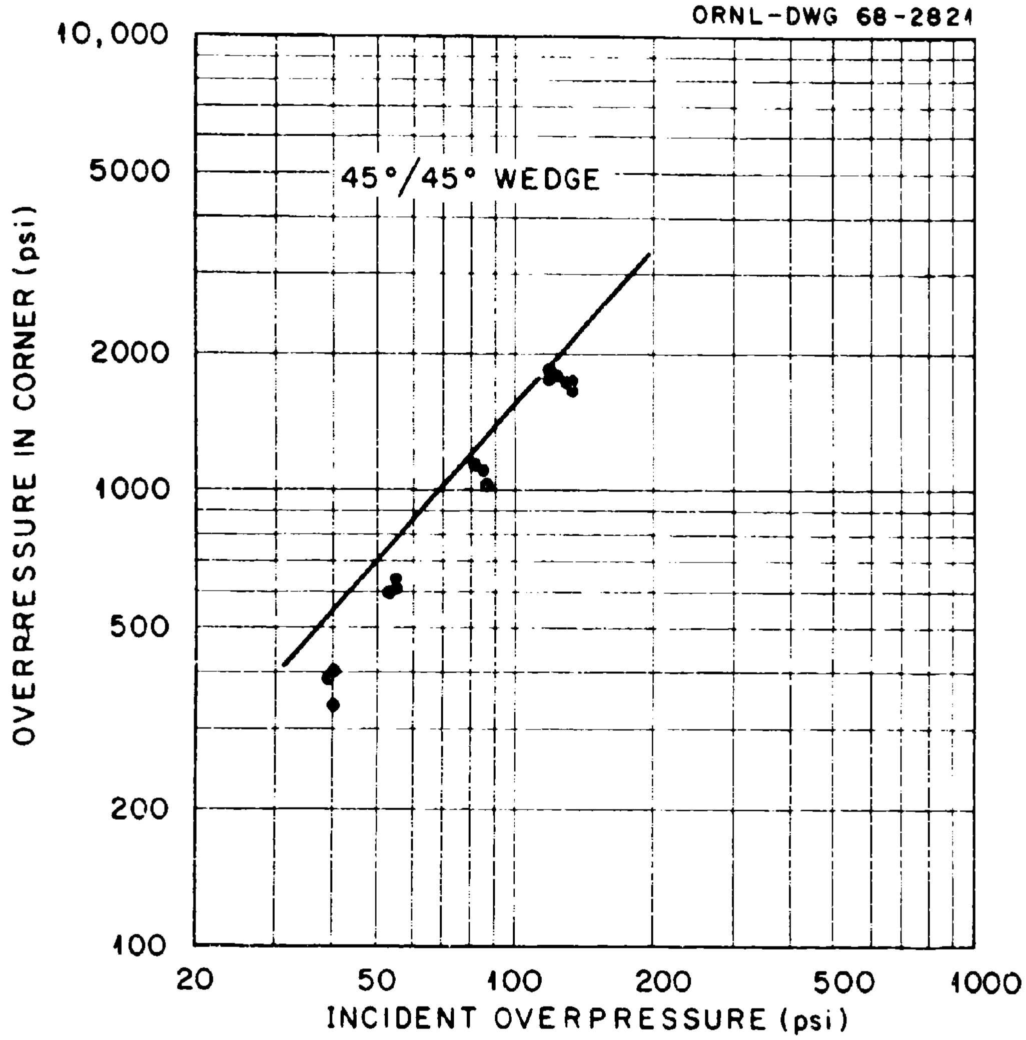


Fig. 11.9 The peak overpressure in the reentrant right angle of the 45°/45° wedge as a function of the incident overpressure.

## 11.5 REFERENCES

1. "Supersonic Flow and Shock Waves," R. Courant and K. O. Friedrichs, Publishers, Inc., New York, 1948, p. 326.

2. Ibid., p. 342.

3. "Regular Reflection of Shocks in Ideal Gases," H. Polacheck and R. J. Seeger, Navy Department Bureau of Ordance, Explosives Research Report No. 13, February 12, 1944; "The Effects of Nuclear Weapons," Samuel Glasstone (ed.), U.S. Government Printing Office, February, 1964, p. 147.

4. "A Four-Inch Shock Tube Driven by an Explosive Gas Mixture," L. Dresner, C. V. Chester, ORNL-TM-2094, March, 1968.

# 12. POWER REACTOR VULNERABILITY TO NUCLEAR WEAPONS

C. V. Chester and R. O. Chester

## 12.1 INTRODUCTION

### 12.1.1 Power Reactors as Targets

A typical 1000 MWe nuclear power reactor has a long-lived fission product inventory in its core equivalent to the yield of a 29 megaton weapon. If a smaller weapon, say 100 KT, can release this inventory, a nuclear reactor might be deliberately targeted.

Figure 1 compares the activity from a 100 KT fission weapon after detonation and from the total inventory of fission products in a 1000 MWe reactor core after shut down. The fuel in the core is assumed to have a three year operating time and to be uniformly rotated so that fuel of all ages between 0 and 3 years is equally represented. The reactor core activity consists primarily of the longer lived isotopes and although initially there is less activity in the reactor core than in the weapon, in less than a day the activity levels are reversed. Now it takes the reactor activity 2 1/2 years to decay to the level of the weapon activity at 2 weeks. After 10 years nearly 50% of the reactor activity is 28y $^{90}Sr$ and 29y $^{137}Cs$. In contrast, another biologically active element with no long lived isotopes, iodine, has a total activity in the reactor core comparable to that in a weapon. The iodine activity in both the weapon and the reactor has essentially disappeared after 2 months.

Building several of these large reactors together on a single site, as most power companies do, tends to make power reactors even more vulnerable. Brown's Ferry, Alabama for example, will have three 1000 MWe reactors arranged in a line 151 feet from reactor center line to reactor center line.

Additionally, there is spent fuel storage adjacent to the reactors. This spent fuel is usually less well protected from blast effects than

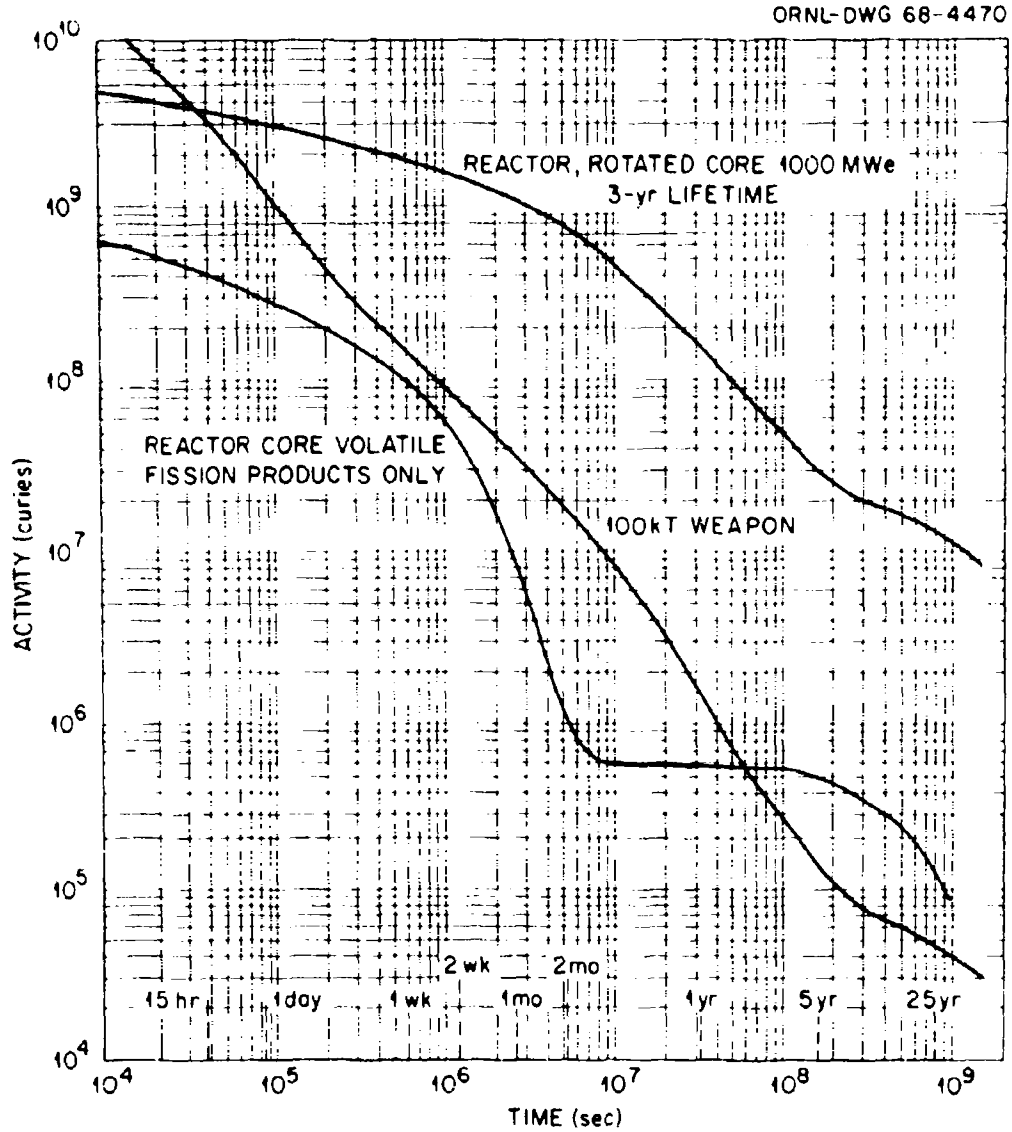


Fig. 12.1. Residual Activity from 1000 MWe Reactor and a 100 KT Weapons vs Time After Weapon Detonation or Reactor Shutdown.

the operating reactor core and could add substantially to the weapon fallout. In some cases fuel recovery plants with fuel storage pits capable of holding many years inventory of fuel will be built close to the large reactors. The MFRP (Midwest Fuel Recovery Plant), for example, is already approved for a site less than one mile from the Dresden power plant containing three reactors. The overall object of this work is to determine just how vulnerable to nuclear attack the large nuclear power plants are.

### 12.1.2 The Test Prototype

The Turkey Point reactor to be built south of Miami was selected as the test prototype for this work. The Turkey Point reactor is a 720 MWe pressurized water reactor. The operating pressure is 2400 psi at 650°F. (See Figure 2.)

The reactor pressure vessel shown in Figure 3 is a steel cylinder 46 feet long with hemispherical ends. The vessel has an inside diameter just under 13 feet and a nine-inch thick wall. The top closure is a hemisphere connected to the cylinder by a bolted flange. The reactor is surrounded by a biological shield of reinforced concrete approximately 68 inches thick. Coolant pumps and steam generators are situated in chambers around the biological shield, and the pumps and generators are surrounded in turn by another concrete wall about 12 inches thick. Finally, the entire reactor is enclosed in a cylindrical containment wall of prestressed concrete 120 feet in diameter and 42 inches thick. The containment wall is designed to withstand a [illegible] mph wind and a 5 psi differential pressure acting simultaneously, missiles consisting of a car traveling at 50 mph, 450 lb bolted wood decking traveling at 500 mph, or 100 lb siding sheet traveling at 600 mph. Tornadoes in the Florida environment are, in part, responsible for the substantial design of the containment wall. A diagram of the principal structural elements of the reactor is shown in Figure 4.

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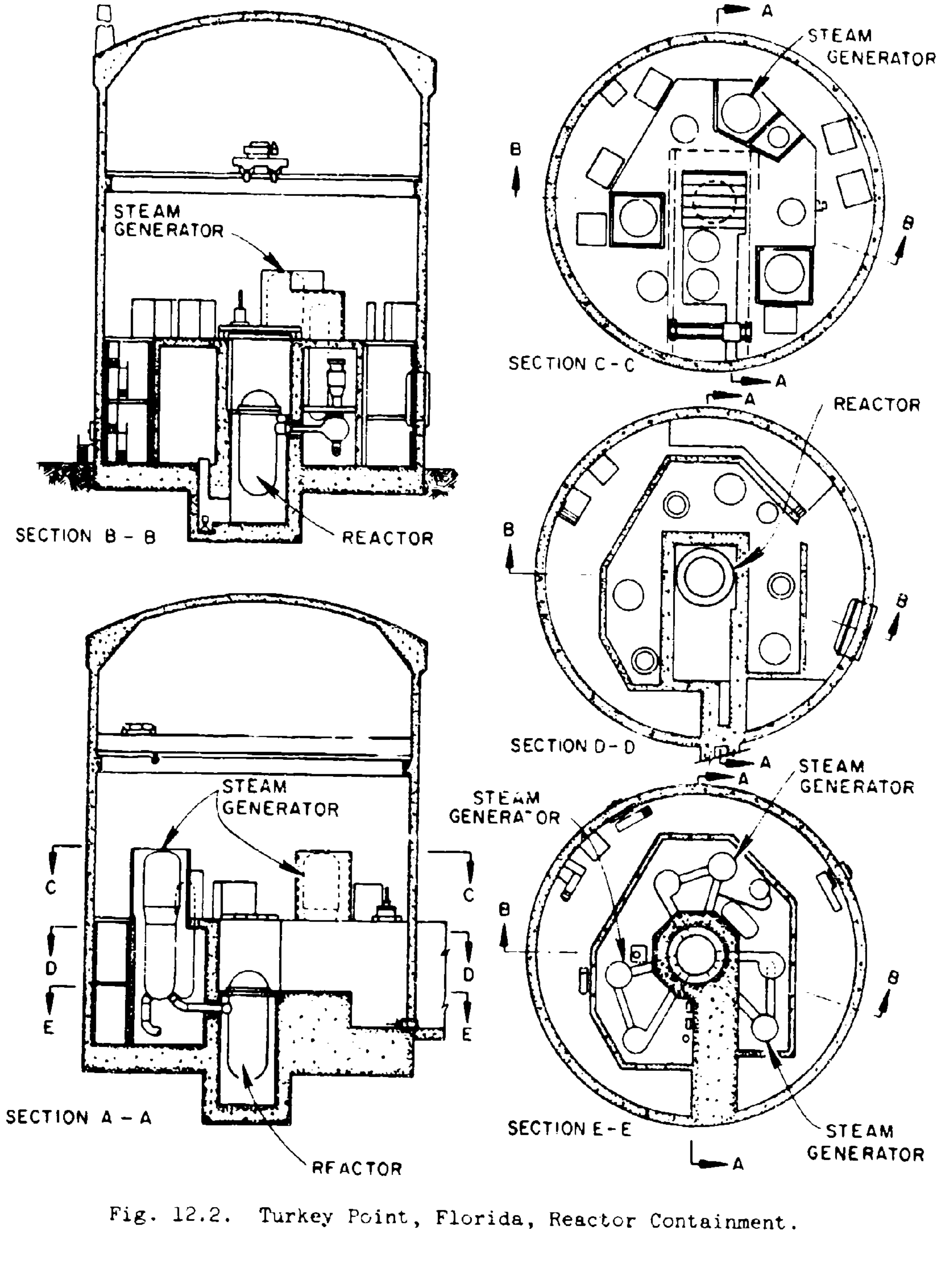


Fig. 12.2. Turkey Point, Florida, Reactor Containment.

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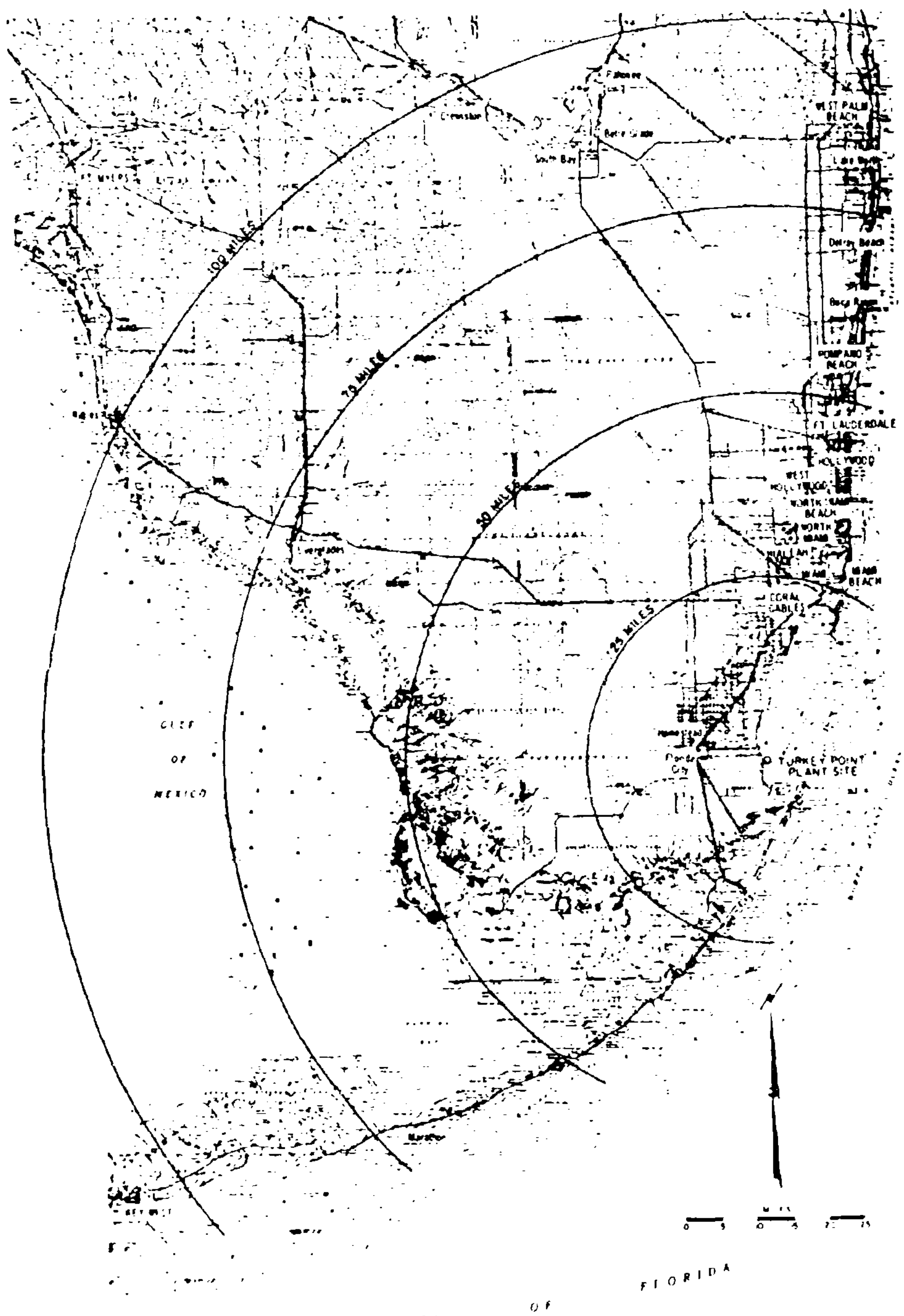


Fig. 12.3. Turkey Point, Florida, Plant Site General Location Map.

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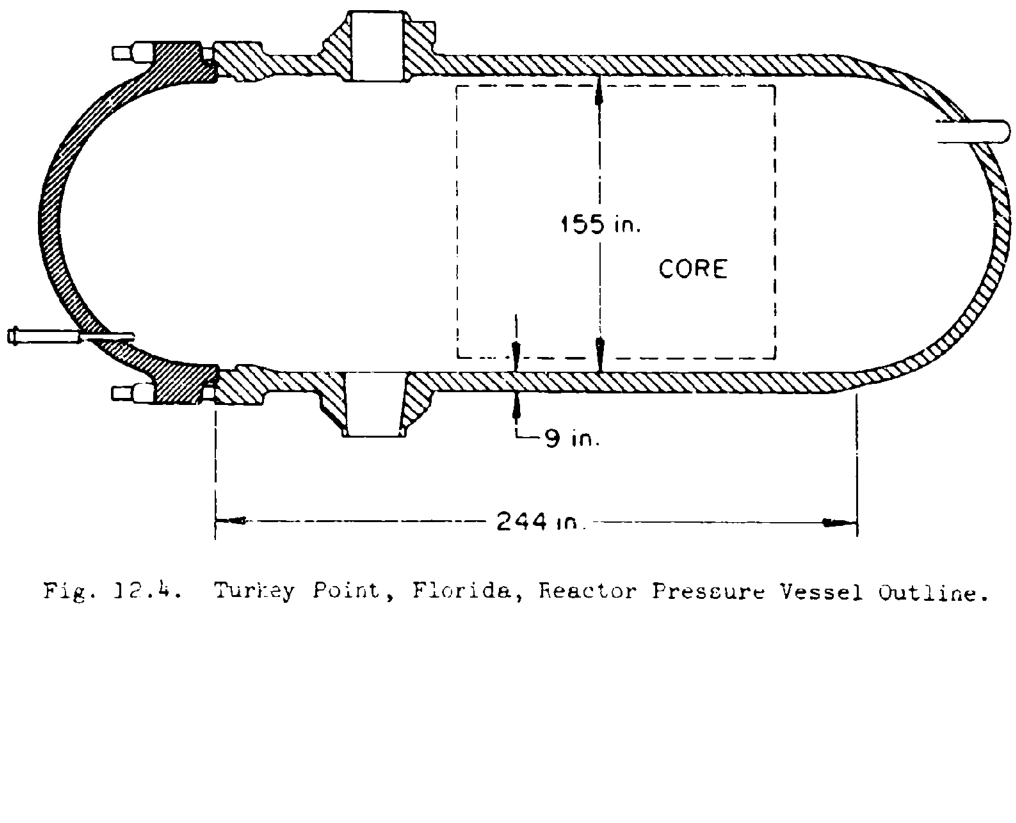


Fig. 12.4. Turkey Point, Florida, Reactor Pressure Vessel Outline.

### 12.1.3 Criterion For Preferentially Targeting a Power Reactor

The criterion for preferentially targeting a power reactor is the production of a significant number of additional casualties due to the presence of the reactor in the target area of a nuclear weapon. By this criterion, damage to the reactor causing a loss-of-coolant meltdown and simultaneous loss of containment would not be significant unless casualties were produced. Nuclear weapons effects on power reactors can be divided into 3 important cases.

The first case occurs when a weapon is detonated far enough from the reactor that the containment wall is subjected to 5 psi or less.[1] A 100 KT weapon detonated 2 miles or more from the reactor falls into this case as does a 10 MT weapon detonated at least 9 miles away. In this case there will be no loss of containment, no activity release, and therefore no additional casualties produced.

The second case occurs when the weapon detonated is close enough to the reactor to produce overpressures sufficient to breach the reactor containment and damage the primary coolant system but not sufficient to rupture the pressure vessel. If the vessel is not breached, except for the coolant lines and minor damage to the integrity of the vessel, the core will remain in the vessel. The vessel itself could be thrown several hundred feet by the explosion. The mode of failure can best be predicted by model studies, reported later. A 100 KT weapon detonated 200 to 6800 feet from the reactor or a 10 MT detonated 2000 feet to 6 miles away would be examples of this second case. It is assumed the engineered reactor safeguards are also damaged and a core meltdown could occur in 1/2 to 2 hours with the consequent release of less volatile fission products.

In order for the fission products in the core to produce significant additional casualties, they must first be moved from the area of immediate weapons effects and then deposited in concentrations that produce dangerous radiation levels. We argue that those fission product vapors escaping from the area of a meltdown will not be deposited downwind in quantities significant compared with the weapon fallout. In

order to be deposited in quantity, the fission products must be mixed with the earth pulled up in the stem of the cloud, and hence must escape from the reactor in large amounts within seconds of the burst. Since minutes are required for the core to melt, the fission products from a core meltdown will not be included in the weapon fallout. The atmospheric effects of the nuclear weapon (except for any large and persistent fires) have occured long before the meltdown, therefore, local meteorological conditions determine the distribution of the radioactivity released from the core. It is highly improbable that the local meteorological conditions will carry enough radioactivity from the reactor core to create serious biological effects outside the region of high-casualties from initial weapon effects. The high casualty region is approximately one mile from ground zero for a 100 KT weapon and nine miles from a 10 MT.

The third case occurs when a nuclear weapon is detonated close enough to the reactor that the impulse per unit area delivered to the containment wall is greater than 100-200 psi-sec. In this case, the reactor pressure vessel is broken open, the fragmented core is ejected from the ruptured pressure vessel is broken open, the fragmented core is ejected from the ruptured pressure vessel and entrained in the stem of the cloud. Fission product release could be significant while the core fragments are in the stem and a fraction of the reactor fission products could be added to the weapon fallout. If this third case is logistically and economically obtainable, a power reactor makes an attractive target.

### 12.1.4 Weapon Effects

At the maximum distance a nuclear weapon can be detonated and still breach a reactor pressure vessel, the most destructive weapon effect is the blast. Ionizing radiation will be essentially excluded from the core by the shielding. Radiation from the thermal pulse will have diffused only a few inches into the outer concrete shell before the arrival of a multi-kilobar shock for detonation close to the reactor. When detonation

takes place at larger distances, the phenomenon of "breakaway" will have occured and the shock wave arrives before the fireball.

The effects of the blast loading on the outer shell have been calculated using the procedures outlined in Glasstone[2] and weapon effects calculated by Hillendahl[3] and are shown in Figure 5. Calculations are for yields and ranges producing impulses that scaled experiments have shown to be in the neighborhood of those just breaching the pressure vessel. Since typical reinforced concrete begins to fail at 5000 psi, the strength of the outer shell may be regarded as small compared to the blast loading. The shell is accelerated to about 2000 ft/sec and thrown against the biological shield of the reactor. A largely inelastic collision occurs and the combined masses impact the pressure vessel, accelerating the pressure vessel to 3 or 4 hundred feet per second. As a result of the impact and depending upon the state of pressurization of the vessel, the bolts holding the top flange may shear and the vessel may split lengthwise on the side opposite the impact.

### 12.1.5 Fission Product Release

Fission product release depends very strongly on whether or not the reactor pressure vessel is throughly fragmented and the crushed and fragmented core is exposed to the atmosphere. There will be a maximum release of fission products if the core fragments are exposed. These core pieces could be picked up with the other debris by the weapon stem winds and reactor fission products might be released and added to the weapon fallout.

The exact fission product release is difficult to estimate. However some very rough estimates are given in "Emergency Core Cooling,"[4] based on small scale release experiments conducted at ORNL.[5] 40 to 90% of the volatiles and "substantial fractions" of the nonvolatiles are estimated to be released from a thoroughly fragmented core. The gaseous fission products that collect in void spaces between fuel and cladding will start escaping as soon as the fuel cladding is fractured by blast effects. The activity of the noble gases and halogens is plotted in

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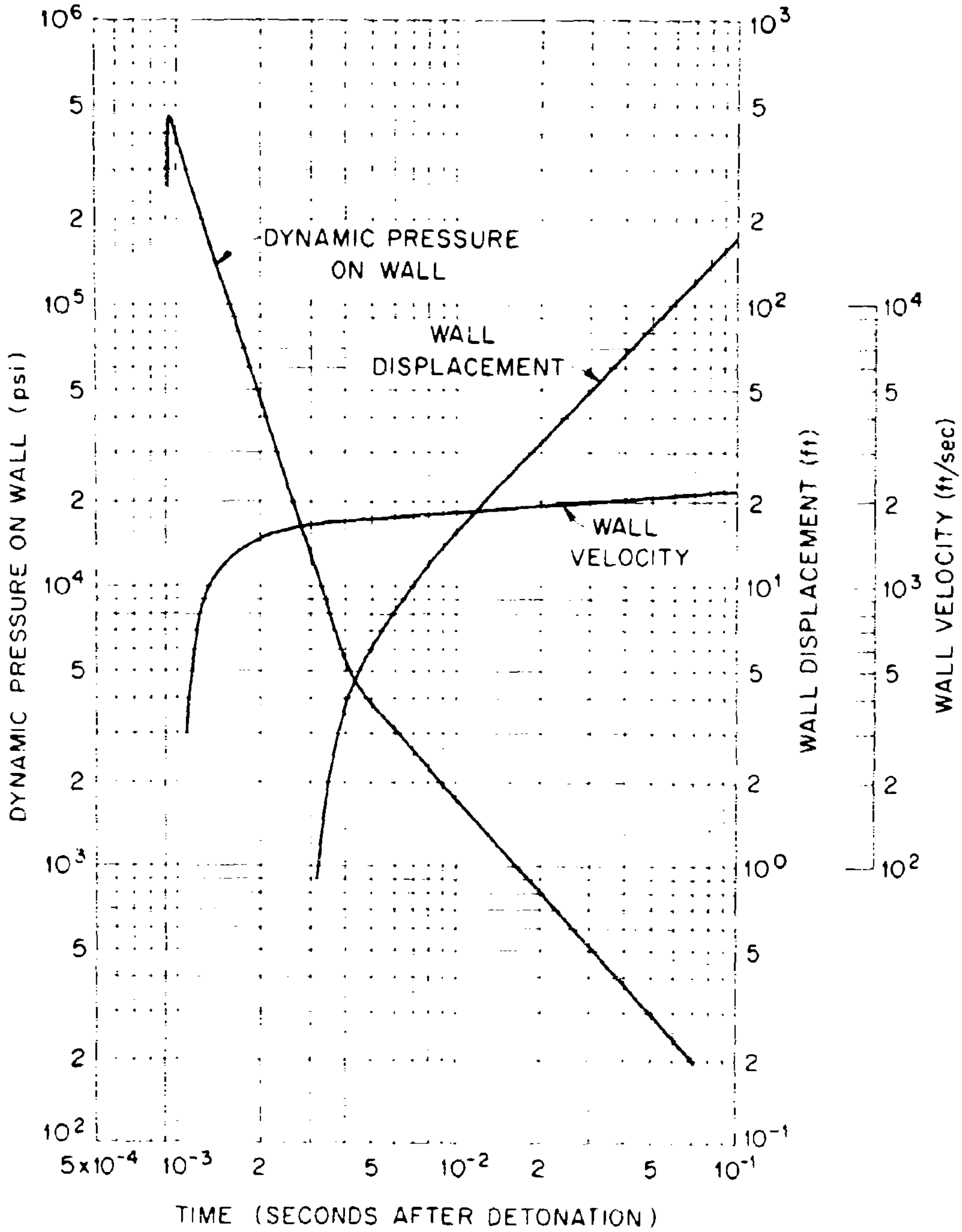


Fig. 12.5. The Effects of a 100 KT Weapon Detonated 200 Feet from the Reactor Containment Wall.

Figure 1. As the temperature of the fuel rises, other fission products become volatile. Ce, Te and Ru, for example, are volatile at the melting point of the cladding. Release of the volatile oxides of ruthenium will be inhibited if there is water present because there will be a water-metal reaction providing a reducing atmosphere which seems to inhibit the Ru oxide release.

When the pieces of core or pressure vessel and core fall back to the ground, any piece of core with enough fission product heating to be molten, and hence a sizable inventory of fission products, will proceed to bury itself by melting its way into the ground. A core contained in the pressure vessel will bury itself after melting thru the pressure vessel because it is heavier than the usual materials of the ground and $UO_2$ has a melting point (5140$^{\circ}$F) above that of ground materials (sand 3100$^{\circ}$F, limestone 4500$^{\circ}$F).

The comparison of the time sequence of weapons effects and reactor blowdown in Table I. will illustrate the probable fission product release procedure.

TABLE I. COMPARISON OF WEAPON EFFECTS AND REACTOR BLOWDOWN

| Time | 100 KT Weapon | 1000 MWe Reactor | |
|---|---|---|---|
| | | Case 1<br>The weapon has ruptured the pressure vessel and the fragmented core is ejected | Case 2<br>The weapon has demolished the reactor containment but the pressure vessel has not ruptured and the crushed core is retained in the pressure vessel |
| - | Detonation 200 feet from reactor containment Shell | | |
| 1 x $10^{-3}$ sec | Shock wave reaches containment shell, overpressure [illegible] x $10^{3}$ bars, shock velocity 6 x $10^{4}$ ft/sec., impulse delivered to shield is 225 psi-sec. | | |
| 1.5 x $10^{-3}$ sec | Fireball reaches containment shell, temperature 2 x $10^{6}$ °K | | |
| 0.1 sec | | Debris of the containment wall and biological shield reaches the reactor pressure vessel and in case 1, ruptures it ejecting the fragmented core, and in case 2 deforms it and blowdown starts. The release of volatile fission products starts (See Figure 1). | |
| 5 to 10 sec | | | 90% of the water in the pressure vessel lost. The core temperature is 320-[illegible]20°C. |
| 10 to 20 sec | Afterwinds start and reach 200 mph | The fragmented core is in the stem and there will be some release of non-volatile fission products. | Non-volatile fission product dissemination will be slowed down by the pressure vessel surrounding the core. |
| [illegible]0 sec | | The largest pieces of core have fallen back to the ground and those with enough fission product heating have started to melt. | The fuel cladding has started to fail from fission product heating. |
| | | Elevated fuel temperatures promote fission product release. | |
| 10 min. | Stem winds essentially over | | |
| 10 to [illegible]0 min. | | | Core in a melted heap in the pressure vessel |
| [illegible]0 to 120 min. | | Large core fragments may melt into the ground | The core has melted through the pressure vessel and starts to melt into the ground |

## 12.2 MODEL TESTS

### 12.2.1 Similitude

In experiments on the effects of shock and blast on structures, it is convenient to reduce the physical size of the test specimen while keeping constant the physical properties of the materials of construction and the transmission medium (air). A physical size reduction of 100 to 1 was selected for convenience. If velocities created in the model are kept the same as in the prototype while physical length is reduced, it follows that velocity, stress, pressure, density, and strain are invariant between model and prototype. As is shown in Table II, time, momentum/unit area, impulse/unit area, and energy/unit area are all reduced by the scale factor of 100. Force and total mass are reduced by the square and cube of the scale factor respectively. Acceleration and vibration frequency are increased by the scale factor.

### 12.2.2 Dissimilarities

Rate-of-strain is increased by a factor of 100 in the model. In some stress regions, the response of concrete is sensitive to strain rate. In these regions, special mixes of concrete would be required to give the model the same dynamic response to load as the prototype. In the experiments at hand, the strength of the concrete is small compared with the forces at work, and no special mix is required.

It was observed experimentally in this work that incident energy/unit area from a chemical explosion charge was not the energy/unit area calculated from the scaling laws from full size nuclear weapon. This is not a failure of the scaling procedure but is caused by the different way energy is transmitted from the explosive charge to target in the full size and scaled cases. In these experiments, a given amount of energy from high explosive delivers a much larger impulse to a unit area target than would be calculated from scaling a nuclear explosion. The discrepancy is due to the very small mass of air in the nuclear explosion, relative to the mass of high explosive gases in the chemical explosion, that is available

TABLE II

Scale Factors for Reactor Model

| Variable | Dimension | Model/Prototype Scale |
|---|---|---|
| Length | $L$ | 1/100 |
| Velocity | $L/T$ | 1/1 |
| Time | $T$ | 1/100 |
| Total mass | $M \propto L^3$ | $1/10^6$ |
| Force | $F = MLT^{-2}$ | $1/10^4$ |
| Stress<br>Pressure | $FL^{-2} = ML^{-1}T^{-2}$ | 1/1 |
| Density | $ML^{-3}$ | 1/1 |
| Acceleration | $LT^{-2}$ | 100/1 |
| Momentum/unit mass | $LT^{-1}$ | 1/1 |
| Momentum/unit area | $ML^{-1}T^{-1}$ | 1/100 |
| Impulse/unit area | $FTL^{-2} = ML^{-1}T^{-1}$ | 1/100 |
| Vibration Frequency | $T^{-1}$ | 100/1 |
| Strain | $LL^{-1}$ | 1/1 |
| Energy/unit area | $ML^{-1}T^{-1}$ | 1/100 |
| Rate of Strain | $T^{-1}$ | 100/1 |

to transmit the impulse from the explosion to the target. In a nuclear explosion all the impulse per square centimeter must be delivered by accelerating a gram or two of air (plus a few milligrams of bomb debris) to a very high velocities. In the chemical explosion, at the same relative distances, there are hundreds of times as much explosion gas to carry the momentum, so it must be accelerated to proportionally less velocity, and requires proportionally less energy. Two methods of producing the scaled explosive blast parameters were used.

The simplest method of doing the experiment depends on the assumptions that (1) the damage done to the contents of the containment shell, including the reactor, is by the moving containment shell or its fragments, and (2) the strength of the containment shell is small compared with the overpressure. If these assumptions are valid, the explosive can be put directly on the outside wall of the containment shell.

Another method of doing the experiments was suggested from correlations in the literature of the velocity imparted to a flying plate by a sheet of explosive.[6] A quantity of explosive can be selected to deliver the same impulse to the plate as the air shock under consideration. In actual practice, the explosive charge required to produce the damage of interest was determined experimentally, and then the impulse calculated. At the impulse levels of interest, a nuclear explosive produces peak pressures of a few kilobars. This can be reproduced in the model by standing the sheet explosive off the target a calculated distance; of the order of an inch in the model.

### 12.2.3 Experiments

The objective of the preliminary experiments was to find the impulse range where the Turkey Point pressure vessel would fail catastrophically, and add its contents to the debris entrained in the stem of the cloud.

A first series of very rough approximation experiments was run using 2-inch pipe nipples to simulate the reactor pressure vessel, a 4-inch ID concrete drain tile to simulate the radiation shield around the reactor, and a piece of 1/2-inch gypsum board to simulate the portion of the containment vessel between the reactor and the explosion.

A more careful model of the reactor pressure vessel fabricated from a 1 1/2-inch sch 80 pipe nipple with welded end caps was included in one shot. The inner wall had been bored circular and then the outer wall turned down to give a wall thickness of 0.090 inches, 1/100 of the Turkey Point dimension. From this series it was determined that the interface between survival and failure of the welded model reactor vessel is at an impulse of about 2 psi-seconds (corresponding to 200 psi-seconds in the full sized reactor) delivered to the containment wall.

A second series was run varying the thickness of the containment shell, using both 2-inch pipe nipples and welded model targets. From this series it was learned that damage to the target correlated well with the kinetic energy per unit area acquired by the containment wall.

In the third series, a 1/100 scale model of the concrete containment shell and reactor shielding cast from plaster of paris was introduced. The effect of pressurizing the reactor vessels and explosive stand-off was explored.

### 12.2.4 Results

A summary of the experiments run to date is compiled in Table III. Under Target are listed the models used for the reactor pressure vessels. The pressures listed in test series 3, indicated by Shot No. 3-0 through 3-6, are the pressures in the model at the time of firing. In every test, the vessel was filled with water. Under shielding are listed the materials used to simulate the radiation shielding around the reactor, and the sectional density in grams/inches$^2$ in the direction of the blast.

Under shell in Table III are listed the various weights per unit area of the materials used to simulate the outer containment shell. For the majority of the tests these were 9-inch by 12-inch pieces of gypsum board, using one to three layers to get the desired weight per unit area.

Under Expl. in Table III is listed the Gm/square-inch and type of explosive used. Gel denotes blasting gelatin, A is DuPont "Detasheet type A," and C is DuPont "Detasheet type C". The explosive energy of gelatin is taken at 1.42 Kcal/gm., "Detasheet type A" at 1.21 Kcal/gm and "Detasheet type C at 1.01 Kcal/gm. The notation "tamped" indicates

TABLE III. SUMMARY OF EXPERIMENTS

| Shot No. | Target | Shielding | Shell Gm/in² | Expl. Gm/in² | α | E | Shell Kcal/in² | Shell MV psi-sec | Kcal/in² on vessel | Damage |
|---|---|---|---|---|---|---|---|---|---|---|
| [illegible] | 2"sch 4[illegible] | [illegible] | 21.5 concr. | 55 60% gel Tamped | 0.55 | .[illegible] | 1[illegible] | 13.[illegible] | 1[illegible] | Fragmented |
| [illegible] | 2"sch [illegible] | 4" tile ([illegible]) | [illegible] gypsum | 56 [illegible]% gel Tamped | 2.[illegible] | .55 | 11.[illegible] | 5.[illegible] | 2.[illegible] | Fragmented |
| [illegible] | 2"sch 4[illegible] | 4" tile | 5.[illegible] | 2 C Tamped | .17 | .[illegible] | .[illegible] | 1.5[illegible] | .21[illegible] | Fragmented |
| [illegible] | 2"sch [illegible] | 4" tile | 5.[illegible] | 4 C Tamped | .[illegible] | .[illegible] | 1.[illegible] | 2.1[illegible] | .[illegible] | 1[illegible]% Flattened |
| [illegible] | welded | 4" tile | 5.[illegible] | 4.5 1[illegible]% gel Tamped | .[illegible] | .[illegible] | [illegible].[illegible]1 | [illegible] | .[illegible] | [illegible]% Flattened |
| [illegible] | 2"sch [illegible] | 4" tile | 13.2 gypsum | 6.[illegible] 1[illegible]% gel | .[illegible]1 | .[illegible] | 1.[illegible] | [illegible].[illegible]1 | .[illegible] | 1[illegible]% Flattened |
| [illegible] | welded | 4" tile | [illegible].[illegible] gypsum | [illegible] A | [illegible] | .[illegible] | 2.[illegible]1 | [illegible] | .[illegible] | Completely burst |
| [illegible] | welded | 4" tile | [illegible].[illegible] gypsum | 4 A Tamped | .[illegible]7 | .[illegible] | 2.[illegible] | 2.[illegible] | .[illegible] | 50% Flattened |
| [illegible] | 2"sch [illegible] | 6" tile (4[illegible] g/in²) | 4[illegible] concr. | 25.4 1[illegible]% gel | .5[illegible] | .[illegible] | [illegible].[illegible]1 | 1[illegible].1 | [illegible].[illegible]1 | 10[illegible]% Flattened |
| [illegible] | 2"sch [illegible] | 6" tile | 47 concr. | 11.[illegible] 1[illegible]% gel Tamped | .1[illegible] | .[illegible] | [illegible] | 2[illegible] | [illegible] | 10[illegible]% Flattened |
| [illegible] | welded | 4" tile | 5.[illegible] gypsum | 15.1 gel + [illegible] A | 3.[illegible] | .[illegible] | (11.[illegible]) | (5.[illegible]) | (2.[illegible]) | Fragmented |
| [illegible] | welded | 4" tile | [illegible].[illegible] gypsum | [illegible] A 1[illegible]" | [illegible] | .[illegible] | (2.[illegible]1) | (3.[illegible]) | ([illegible]) | [illegible]% Flattened |
| [illegible] | welded [illegible] psi | Plaster model (1[illegible].7 g/in²) | [illegible].[illegible] plaster | [illegible] C | .5[illegible] | .[illegible] | 1.[illegible] | 2.[illegible]1 | .[illegible] | 1[illegible]% Flat. split (Hit stake) |
| [illegible] | welded 1[illegible] psi | Plaster model | 9.[illegible] plaster | [illegible] A [illegible]" | 0.[illegible] | .2[illegible] | ([illegible]1) | (3.3[illegible]) | (1.[illegible]) | Small Dent |
| [illegible] | welded 15.[illegible] psi | Plaster model | 9.[illegible] plaster | [illegible] A 1[illegible]" | .[illegible]7 | .2[illegible] | ([illegible]1) | (3.3[illegible]) | (1.[illegible]) | 2" split |
| [illegible] | welded [illegible]5 psi | Plaster model | 9.[illegible] plaster | 8 A 12" | .[illegible] | .2[illegible] | ([illegible]1) | (3.3[illegible]) | (1.[illegible]) | 1[illegible]% Flat |
| [illegible] | [illegible]lted closure | 4" tile | [illegible].[illegible] gypsum | [illegible] C | .[illegible]55 | .21[illegible] | [illegible] | 1.[illegible] | .[illegible] | [illegible]% Flat. All bolts broken |

that the charge was tamped with a mass equal to the shell mass.

The distances given in series 3 are standoff distances between the charge and the shell. In these experiments the charge was placed in a 10-inch ID by 1 1/4-inch wall concrete tile, oriented to function as an expendable shock tube and direct the shock against the shell.

Under $\alpha$ is tabulated the ratio of mass per unit area of explosive to that of shell plus tamping. E is the fraction of explosive energy converted to kinetic energy of the shell and tamping, calculated from literature correlations.[6] This kinetic energy in Kcal/inch$^2$ is listed for the shell in the next column. The momentum of the shell is given in the next column.

Assuming conservation of momentum and a perfectly inelastic collision of the shell with the shielding, the kinetic energy of the combined mass was calculated and is listed in the next column. This is the kinetic energy of the mass impacting the reactor vessel near its centerline.

The numbers in parentheses in this and the previous two columns in series 3 are upper limits, assuming no energy losses as the blast traveled down the disintegrating concrete shock-tube to the target.

The damage produced on each specimen is listed in the last column. The damage may be more clearly seen in Figures 6, 7, and 8, which are photographs of the specimens after the shots.

### 12.2.5 Conclusions from Model Tests

1. A welded, unpressurized model vessel will be lightly damaged by an impulse of 1.0 psi-seconds delivered to outside wall, moderately damages by 2.0 psi-seconds, and destroyed by 3.20 psi-seconds.

2. Pressurizing the vessel reduces the impulse required to rupture the vessel. Rupture mechanism is tensile failure of the downwind side.

3. The bolted closure may be the weakest part of the vessel under side-on impact. This will be difficult to assess quantitatively because of the difficulty of constructing accurate small models of the closure. Vulnerability may be a very strong inverse function of bolt ductility.

PHOTO 91085

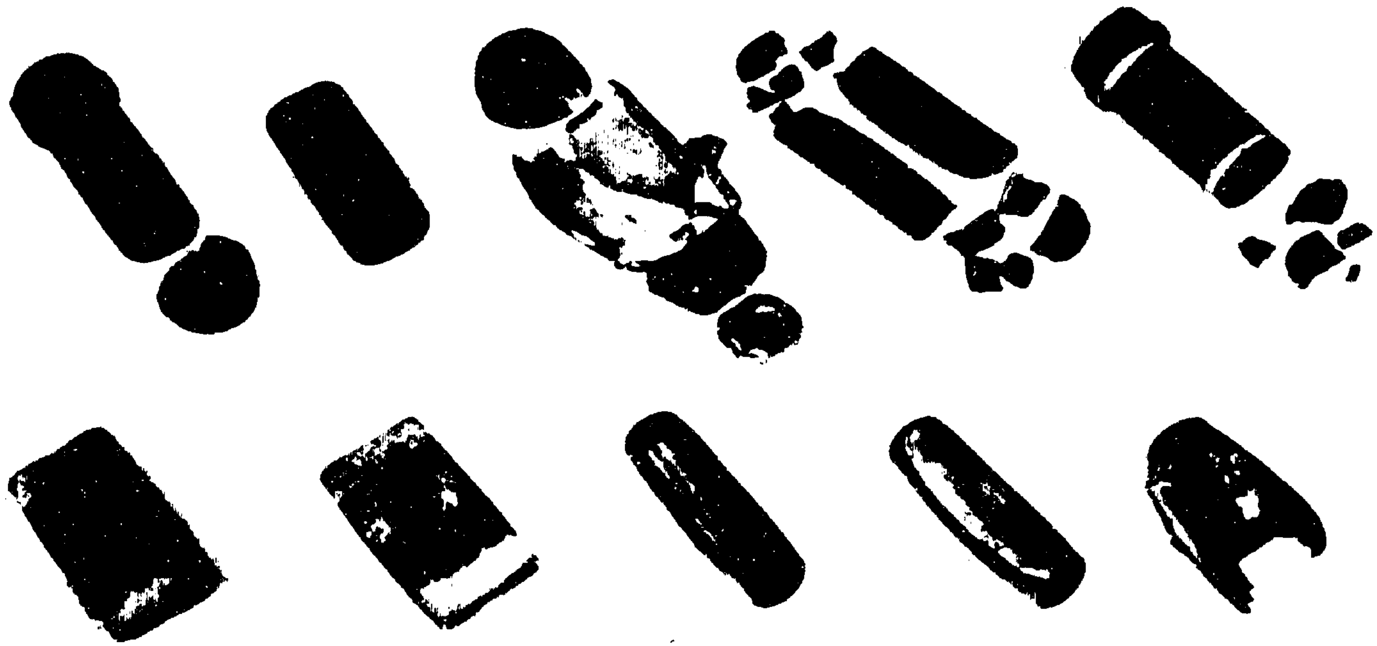

Fig. 12.6 Models of the Reactor Pressure Vessel (See Table III).

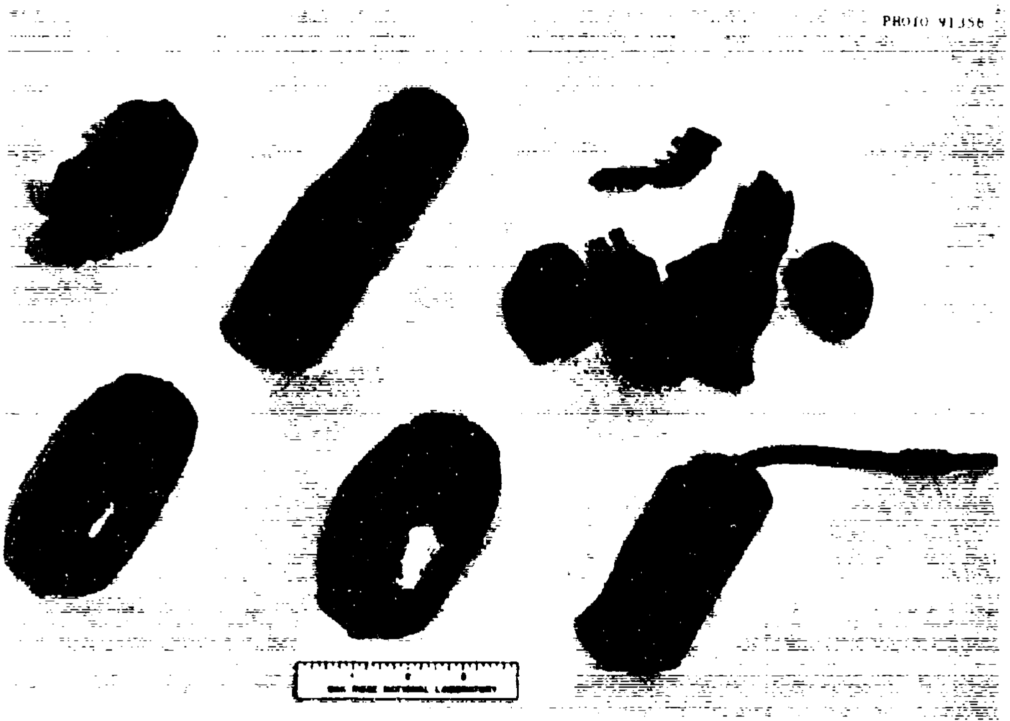


Fig. 12.7. Models of the Reactor Vessel (See Table III).

PHOTO 91351

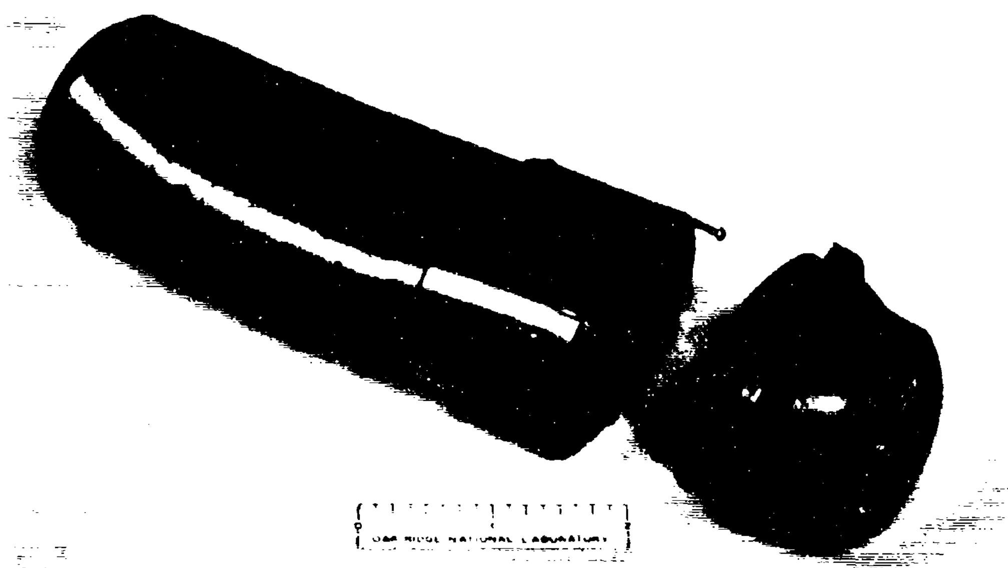

Fig. 12.8. Models of the Reactor Pressure Vessel (See Table III).

### 12.2.6 Recommendations for Future Tests

With the technology that has been developed it is possible to explore a variety of overpressure regions on reactor models. It would be interesting to determine the maximum overpressure that the primary loop could survive. It would also be interesting to compare the rupture pressure of the pressurized-water reactor vessel with that of the boiling-water vessel and a prestressed concrete pressure vessel.

At lower overpressures, gravitational forces begin to become important. These could be accurately simulated by subjecting the model to an upward acceleration of 100 g's for a distance equal to the height of the model, to commence when the shock reached the model. This might be done by giving the model and explosive assembly a downward velocity of 80 ft/second, possibly by dropping it 100 feet, and then decelerating it in one foot with a constant force, possibly by crushing an appropriately sized pad of aluminum honeycomb. For pressures in the neighborhood of a few hundred psi, a shock tube would have to be used for this experiment to reduce the overpressure to the right value. If the required length of tube were much more than a meter, it would probably be easier to design the experiment with a larger diameter tube which remained stationary while the model was decelerated across its mouth.

### 12.2.7 Significance

The model tests indicate that impulses of the order of 100 psi-seconds delivered to the containment shell will be survived by the depressurized reactor pressure vessel. With minor modifications to the vessel and containment structure this could easily be increased to 200 psi-seconds.

Figure 9 shows the variation of impulse to a vertical wall with miss distance for 100 Kt and 35 Kt ground burst. The impulse decreases very nearly linearly with miss distance. For 100 Kt surface burst, a miss distance of 220 feet must be achieved to deliver an impulse of 200 psi-seconds. A distance of 450 feet will reduce the impulse to 100 psi-seconds.

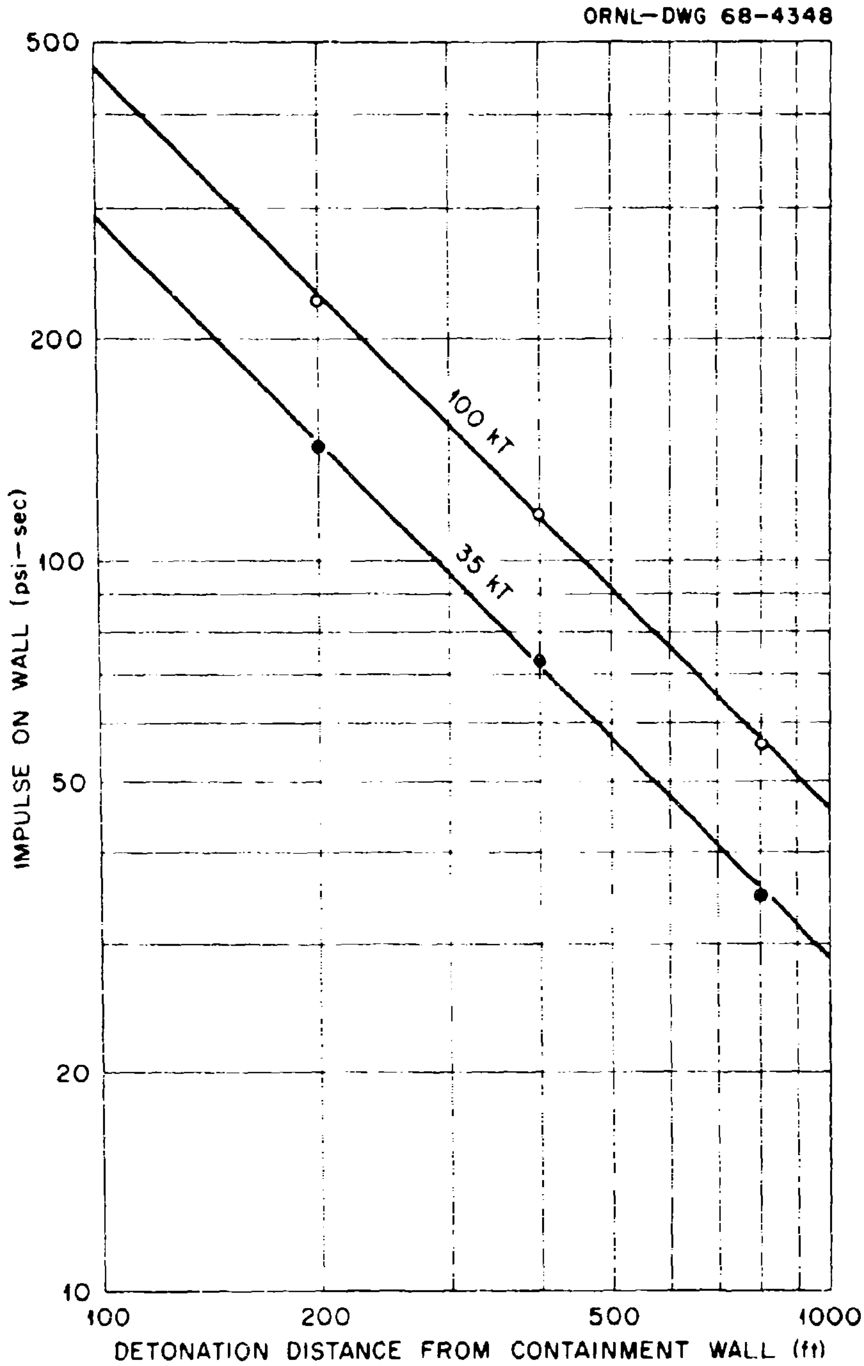


Fig. 12.9. Impulse Delivered to Containment Wall Versus Detonation Distance from the Wall.

These distances are small compared with the order of magnitude of miss distances for ICBM's. If one assumes a Circle of Equal Probability, or CEP, of 0.5 nautical mile for a system delivering weapons of any given yield, the number of weapons required for a given probability of delivering a given impulse to the target can be calculated. Figure 10 is a plot of the number of weapons required for a 50% probability of giving an impulse of 200 psi-seconds to a target as a function of yield. From this figure, 78 100-Kt weapons are required for a 50% probability of delivering 100 psi-seconds to the side of a target 120 feet in diameter. This is very expensive to the strategic planner.

The situation of multiple weapons is much more complicated than is indicated by this simple calculation. Previous weapons can both blow away the protective concrete, increasing the vulnerability of the vessel, or can bury or eject the vessel from the target area, decreasing its vulnerability.

Figure 11 is a drawing of the containment shell superimposed on a drawing of a 100-Kt crater, showing the position of the shell where it would receive 200 psi-seconds and providing a qualitative indication of the magnitude of the hardness of the pressure vessel.

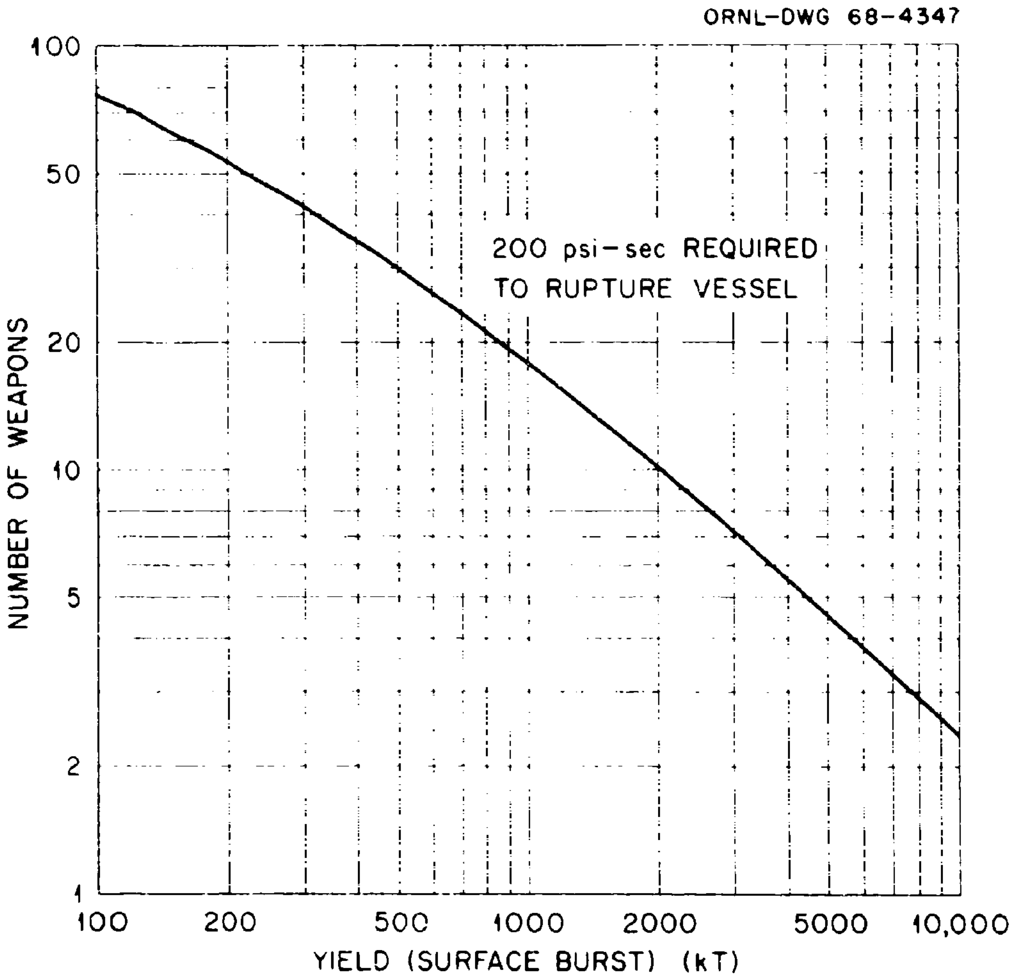


Fig. 12.10. The Number of Nuclear Weapons Targeted on one Reactor for 50% Probability of Rupturing the Pressure Vessel Versus Weapon Yield. Weapon CEP = 0.5 mile.

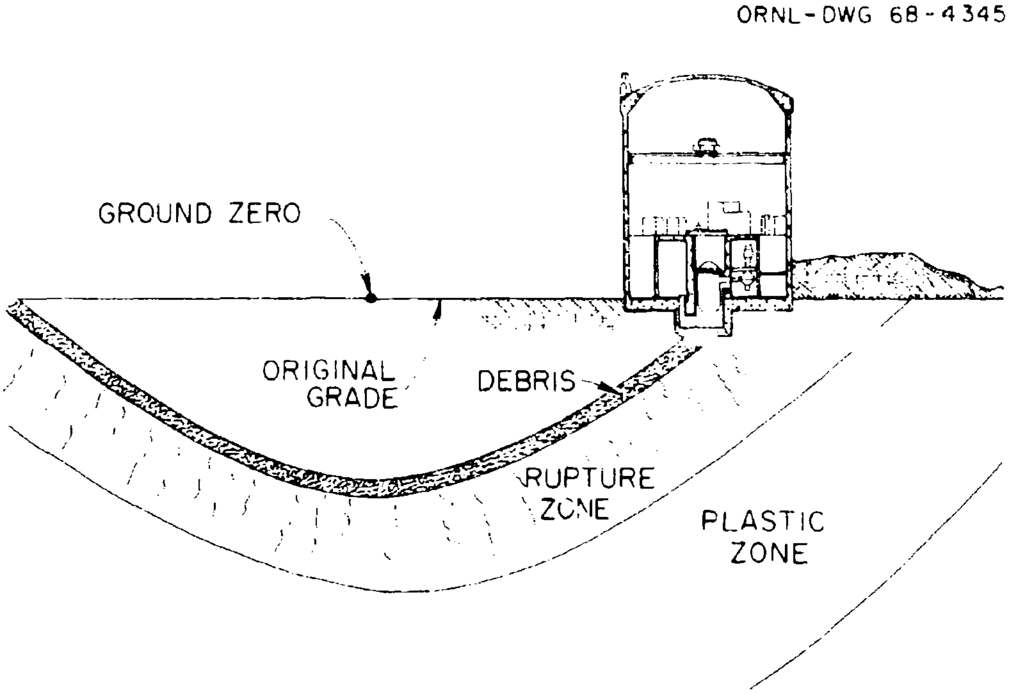


Fig. 12.11 Crater Outline of a 100 KT nuclear Weapon Detonated 220 Feet from the Reactor Containment wall.

## 12.3 ACKNOWLEDGEMENTS

The authors are indebted to W. K. Ergen and A. P. Freas for thoughtful discussions and reviewing the manuscript. C. B. Brooks and H. A. Adams provided invaluable assistance with the experimental efforts.

## 12.4 REFERENCES


1. BNL-6080, A comparison of the Nuclear Defense Capabilities of Nuclear and Coal-Fired Power Plants. May 1962.

2. Glasstone, Samuel, "The Effects of Nuclear Weapons" USDOD and USAEC, April 1962.

3. Hillendahl, R. W., "Theoretical Models for Nuclear Fireballs (U)" IMSC-B006760, March 1966 (SRD).

4. E. G. Ergen, "Emergency Core Cooling, Report of Advisory Task Force on Power Reactor Emergency Cooling" TID-24226, 1967.

5. Nuclear Safety Program Semiannual Progress Report for Period Ending June 30, 1965. ORNL-3943, September 1965.

6. Hoskin, N. E., JWS Allan, W. A. Bailey, J. W. Lethaby, and I. C. Skidmore; "The Motion of Plates and Cylinders Driven by Detonation Waves at Tangential Incidence." Proc. 4th Symp. on Detonation, October 1965, US Naval Ordance Laboratory, White Oak, Maryland.

# VI. SOCIAL ASPECTS OF CIVIL DEFENSE

## 13. STRATEGIC INTERACTION*

David B. Bobrow

### 13.1 INTRODUCTION

This project has two objectives. The first is to clarify the international consequences of different American continental defense postures. The second is to develop data, theory and techniques which will improve understanding of the present and future national security environment. We use political and psychological analyses to pursue these objectives because we feel economic and technological analyses alone provide an insufficient basis for defense policy choices. This report: (1) summarizes the rationale for and the nature of the data we have generated from Chinese Communist public statements; (2) gives examples of findings about Chinese elite attention to different actors in the international system;** (3) gives examples of findings about Chinese elite images of principal strategic actors; and (4) suggest future work involving our Chinese public communications data.

### 13.2 RATIONALE AND DATA BASE

The point of American national security policies is to improve the safety of the United States against threats from currently and potentially hostile members of the international system. Accordingly, if our policies are to achieve their point, i.e., increase the security of this country,

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*This report does not assume a professional social science audience, and our presentation and inclusion decisions reflect this.

**During a summer in residence, Theodore Jaquency of Stanford University did much of this aspect of the analysis. Neal and Eila Cutler provided assistance with programs and computer runs.

American officials need to know which members of the international system represent a genuine threat -- as opposed to an irritation -- to this country and what effects alternative policies will have on the behavior of these genuinely threatening states. That is, national security decision-making is improved to the extent that we have refined and manipulated data that let us describe what properties nations have, observe what these nations are doing so we can chart alterations in these properties (monitoring), and predict the effects of alternative American policies on these properties. The data used for this report were developed for these three purposes.

It seems useful to relate the work reported here to earlier parts of the strategic interaction project. The first stage of the project, a qualitative examination of Chinese Communist public communications, showed that the CCP (Chinese Communist Party) views the elements of military power and the determinants of conflict between states very differently from Western or Soviet strategic analysts.[1] Accordingly, the Chinese response to a super-power continental defense decision (e.g., U.S. ABM deployment) is calculated on the basis of a very different strategic model. This initial research dealt only with the beliefs and values of the Chinese elite, largely as they derived from the historical experiences of the CCP. Clearly, such an analysis was undesirably imprecise in its data and conclusions and undesirably restricted in the variables used.

Accordingly, the second stage of the project re-analyzed quantitative data collected in terms of "objective" economic, military, and political variables and data derived from quantitative content analysis of Chinese communications.[2] The re-analysis indicated that: (a) without understanding the political psychology of Chinese elite decision making, we could not arrive at an adequate understanding of China's national security behavior; and (b) Chinese elite decision-making could not be validly described as dispositionally irrational, undifferentiated or rigid in their responses, as these terms were defined in the re-analysis.

Accordingly, the third stage of the strategic interaction project has consisted of building and analyzing a data base which: (a) deals with

the political psychology of Chinese elite decision-making; and (b) allows us to distinguish different levels of rationality (i.e., means-ends consistency), differentiation and flexibility. For the reasons states last year,[3] we used summaries prepared by the editors of People's Daily, and, after assembling a raw data set covering the years 1960 through 1964, prepared fifteen weeks for analysis. The weeks were deliberately selected to represent different event climates in each of the five years for which we had data.* Because the data are collected for several years, we can look for over-time trends, i.e., we can treat the People's Daily summaries as the equivalent of a respondent to whom one returns several times and whose responses one compares to each other to assess the impact of intervening events.[4] Because the data are collected for several events climates (international, domestic, and cermonial), we can look for different standard sets of responses on the part of CCP leaders. Deviation from the "standard" response in a particular event climate alerts us to the possibility of policy actions different from the ones we have observed the Chinese to take in the past.

Three limitations of the data prepared for analysis should be kept in mind. First, because of the experimental nature of our research strategy, we prepared only a small volume of data for analysis and did not use sampling criteria which are compatible with customary tests of

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*A. Cermonial: National Day (Sept. 29 through Oct. 5, 1960). National Day (Sept. 29 through Oct. 5, 1961), National Day (Sept. 29 through Oct. 5, 1962), National Day (Sept. 29 through Oct. 5, 1963), National Day (Sept. 29 through Oct. 5, 1964).

B. International: World Federation of Trade Unions Meeting in Peking Ends (June 7 through 1[illegible], 1960), Cease-fire in Laos (May 1 through 7, 1961), Sino-Indian Conflict Begins (October 13 through 2[illegible], 1962), Test-Ban treaty Signed (July 2[illegible] through 29, 1963), Tonkin Gulf Crisis (August [illegible] through 9, 1964).

C. Domestic: Writers Conference Ends (August 11 through 17, 1960), Ninth Plenum (retreat from the "Great Leap Forward") Ends (January 1[illegible] through 22, 1961), Third Session of the 2nd National People's Congress Ends (April 1[illegible] through 2[illegible], 1962), Regulations on Political Work in the People's Liberation Army Issued (March 25 through 31, 1963), Young Communist League Work Conference Ends (March [illegible] through 1[illegible], 1964).

significance. Second, we analyzed only statements by the Chinese elite, not their commitment of economic or military resources. Third, we analyzed only statement in public Chinese media. Of course, Chinese elite -- or, for that matter, American elite -- statements in public media differ from what is being said in restricted circulation documents. To further complicate matters, the Chinese elite sees People's Daily as a way of communicating with audiences that matter outside of as well as within the People's Republic. These three limitations cannot be ignored. However, they do not deprive the data of usefulness for generating hypotheses and there are feasible ways of relaxing all three constraints (see section 13.5 of this report). In the meantime, we have an accessible and potentially valid indicator of Chinese elite perspectives on the CPR and its international relationships, perspectives which the regime is anxious to inculcate as a basis for policy support in the relatively small and important group of citizens who read People's Daily.

## 13.3 ATTENTION TO PARTS OF THE INTERNATIONAL SYSTEM

In this and the next section we present and discuss examples of findings. In each section, we will present, first, a finding from the data, second, hypotheses about the "reasons" for the finding, and, third, some of the implications of the finding for U. S. national security. In both sections, we will restrict ourselves to attributes of the full data set, and not compare the different time periods which it contains.

The findings which follow deal with the relative amount of attention which Chinese communications allot to different regions or countries of the internation l system. What does amount of attention indicate? Several rough rules of inference seem useful. Persistently high attention in public communications suggests that the subject is seen by the communicators as important and stable in the role (e.g., "enemy") which it plays vis-a-vis China. Persistently low attention suggests that the subject is seen as relatively unimportant (e.g., Jordan, in the case of our data). Marked and repeated fluctuations in attention suggest that the subject is seen as important and unstable in its behavior (e.g., India, in our data). Accordingly, the communicators find that their treatment of that actor must

vary as does their policy toward it. Finally, marked but rare instances of high attention suggest that the subject in particular is of no special interest and is being used primarily as an example [e.g., the Congo (Brazzaville) in our data]. These rules have to be used discriminatingly, i.e., the coder has to be sensitive to discrepancies in the data. One sort of discrepancy is inattention to one member of a class of objects when most of the other members receive a great deal of attention (e.g., the lack of attention in our data to Thailand relative to other Southeast Asian nations). Cases of this sort suggest the rule that elites view their relations with the discrepant class member as too complex and/or too uncontrollable to warrant sharing their perspectives with the public.

1. The developing areas of the Middle East, Africa, and Latin America receive low attention. The two notable exceptions are Algeria and Cuba. The data supporting this finding are reported in rows 1-6 of Table I. These data suggest the following hypotheses:

--- The Chinese elite views the Middle East, Latin America, and, to only a slightly lesser extent, Africa as zones of secondary rather than primary importance.

--- The exceptional (not demonstrated by the data yet read) attention given to Algeria and Cuba may indicate that the Chinese elites: (a) limit their public commitments in the distant developing areas of revolutions which have already secured power (there were insurgent, i.e., not incumbent, revolutionary movements in the relevant geographical areas which did not receive similar attention); (b) see as stable actors (vis-a-vis Chinese policy) only Middle Eastern, African, and Latin American regimes committed to eroding the regional influence of major Western states and to exporting a national liberation war model; (c) adopt such regimes in order to compensate for limited Chinese resources to intervene in distant parts of the world and to increase the relevance and local quality of the liberation war approach to the international system.

If these hypotheses are valid, two predictions are warranted. First, Chinese will not respond in a manner which is expensive for them to

TABLE I

Regional Attention

(as mean % of mentions of all countries other than China)

| Region: | Year: A. 1960 | B. 1961 | C. 1962 | D. 1963 | E. 1964 | Event Climate: F. Domestic Event | G. International Event | H. Ceremonial Event | Total: I. |
|---|---|---|---|---|---|---|---|---|---|
| 1. Middle East | 1.5% | 0.9% | 0% | 0% | 0% | 0.5% | 0% | 0.9% | 0.5% |
| 2. Latin America (other than Cuba) | 0 | 1.1 | 0.9 | 1.6 | 2.3 | 3.5 | 0.3 | 0 | 1.3 |
| 3. Africa (other than Algeria) | 9.0 | 3.0 | 1.9 | 3.1 | 16.9 | 5.2 | 5.3 | 9.8 | 6.8 |
| 4. Sub Total: | 10.5 | 5.0 | 2.8 | 4.7 | 19.2 | 9.2 | 5.6 | 10.7 | 8.6 |
| 5. C[illegible] | 3.3 | 8.2 | 9.6 | 18.2 | 2.2 | 8.0 | 8.7 | 7.9 | 8.2 |
| 6. Algeria | 1.3 | 0 | 3.9 | 5.2 | 0 | 1.0 | 0.3 | 4.9 | 2.0 |
| 7. Eastern Europe (other than Albania) | 0 | 9.4 | 0.6 | 2.4 | 6.4 | 1.4 | 1.4 | 8.5 | 3.8 |
| 8. Western Europe and Old Commonwealth: | 0 | 0.9 | 3.0 | 2.4 | 2.0 | 2.3 | 2.7 | 0 | 1.7 |
| 9. Sub Total | 0 | 10.3 | 3.6 | 4.8 | 8.4 | 3.7 | 4.1 | 8.5 | 5.5 |

American defense policies which bear primarily on the Middle East, Africa, or Latin America. Second, the Chinese will be extremely sensitive to U. S. political-military decisions which curtail the autonomy of militance of Cuba and Algeria; however, any action response will probably not be in that region.

2. Western Europe, the Old Commonwealth, and Eastern Europe (with the exceptions of the U.S.S.R. and Albania) receive little attention. Relevant data appear in rows 7-9 of Table I. This finding implies the following hypotheses:

--- With the exceptions noted, the Chinese elite views Western Europe, the Old Commonwealth, and Eastern Europe as zones of secondary rather than primary importance.

--- Since the inattention does not vary with current political alignment, i.e., Warsaw Pact or NATO membership, we may be able to account for the inattention by common attributes such as these: (a) distance from the CPR; (b) industrialization (c) no recent experience as Western colony; and (d) Caucasian population.

We predict that China will make no major response to American national security policies which primarily affect Europe, the Europe-centered alliances or the Old Commonwealth countries. For example, U. S. deployment of ABMs in Europe will not intersect with, and therefore not defend us against, Chinese objectives.

We now turn from regions as subjects of attention to particular countries: what countries are treated as the core elements of the CPR international system? Table II presents the relevant data. The rows in the table contain political units, primarily countries, which had: (a) an attention score of more than a 0.5 standard deviation above the mean for at least two weeks; and (b) a mean attention score of more than a 0.5 standard deviation above the mean for at least one of our summary analytic units (either a year or an event climate type). The table gives the number of weeks in which an actor met the first criterion (column A) and the mean Z score for each year (column B-F) and event climate (columns G-I).

TABLE II

The Core International System

| Name of Actor: | A. No. of High Attention Weeks (Max = 15) | Mean Z Scores | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | B. 1960 | C. 1961 | D. 1962 | E. 1963 | F. 1964 | G. Domestic Event | H. International Event | I. Ceremonial Event |
| C.P.R. | 15 | [illegible] | 2.580 | 7.620 | [illegible] | [illegible] | 5.745 | 3.483 | [illegible] |
| Japan | 12 | 3.458 | [illegible] | 1.151 | [illegible] | [illegible] | 1.872 | [illegible] | [illegible] |
| U.S.A. | 11 | 2.138 | [illegible] | 1.920 | 2.161 | [illegible] | 3.375 | [illegible] | [illegible] |
| Cuba | 9 | [illegible] | [illegible] | [illegible] | 3.854 | .191 | 1.551 | [illegible] | [illegible] |
| No. Korea | 8 | 2.718 | [illegible] | .271 | 2.361 | [illegible] | 2.046 | [illegible] | [illegible] |
| No. Vietnam | 7 | [illegible] | .960 | [illegible] | -.155 | 1.690 | [illegible] | [illegible] | [illegible] |
| Laos | 6 | [illegible] | [illegible] | [illegible] | -.304 | [illegible] | 0.937 | 1.575 | [illegible] |
| Albania | 5 | [illegible] | [illegible] | [illegible] | .241 | .030 | -.008 | [illegible] | [illegible] |
| U.S.S.R. | 5 | [illegible] | 3.117 | .455 | -.161 | .102 | 1.327 | [illegible] | [illegible] |
| India | 4 | [illegible] | [illegible] | [illegible] | 1.315 | [illegible] | 0.772 | 1.446 | [illegible] |
| Algeria | 3 | [illegible] | [illegible] | .360 | .626 | -.200 | -.075 | [illegible] | [illegible] |
| So. Vietnam | 3 | [illegible] | [illegible] | [illegible] | [illegible] | 1.345 | .814 | .103 | [illegible] |
| Burma | 2 | [illegible] | [illegible] | -.249 | [illegible] | -.200 | -.041 | [illegible] | [illegible] |
| Nepal | 2 | [illegible] | 1.504 | .124 | [illegible] | [illegible] | [illegible] | -.263 | [illegible] |
| Rumania | 2 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | -.081 | [illegible] | [illegible] |
| Vietnam (Unspecified) | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |

3. The most persistently noticed actors in the international system are China herself and two countries which the Chinese define as "enemies" -- Japan and the United States. Attention to the Soviet Union fluctuates sharply, i.e., is not consistently high. These findings suggest that:

--- The Chinese elite see the relationship between the C.P.R. and Japan and the U.S. as relatively stable compared to that between China and the U.S.S.R.

--- The CCP sees Japan as the major Asian competitor with China.

The findings and hypothese lead to two predictions. First, U. S. national security planning should anticipate sizeable fluctuations in Sino-Soviet relations, fluctuations much greater than those in Sino-American or Sino-Japanese relations. Second, U. S. planners should expect that the likelihood that our strategic decisions will lead the CCP to alter its policies increases sharply as our decisions affect Japan's political-military relationships with the international system, e.g., a U. S. ABM deployment in Japan.

4. The core international system over-represents the traditional or classic zones of Imperial Chinese interest.[5] The current territorial domains of many of the actors in Table II overlap with the tributary sphere of Imperial China: North Korea, North Vietnam, Laos, U.S.S.R., India, South Vietnam, Burma, Nepal, and Vietnam (unclear zone reference). This finding suggests that:

--- The Chinese elite accord great importance to the territorial priorities established by imperial tradition.

--- The presence of an "old geopolitics" models increase the probability that the CCP is using an old model of relationships with these areas: that of suzerainty rather than direct rule.

We predict that if the United States implements strategic decisions which seek to deny Communist China the sphere of influence of Imperial China, these decisions will reaffirm CCP beliefs that we are hostile and will mobilize Chinese Communist strategies to decrease our general national security and international position. These strategies will not necessarily be military in nature, aimed at the same region, nor explicitly connected with these specifically offending decisions.

5. In addition to the major competitor and traditional elements in the core international system, analysis of the communications data discriminates four other actors from the universe of nations: Cuba, Algeria, Albania, and Rumania. Their presence suggests that:

--- The Chinese elite see as important those actors whose policies fragment the sphere of influence of major competitors. The notion of subtracting from the resources of one's competitor by acting through third parties has many precedents in the behavior of states. The use of this strategy by Chinese elites, Imperial or Communist, is not new; what is new is using the strategy in territories so distant from the Chinese mainland.

We predict that American actions run counter to Chinese plans as they increase the cohesion of either American or Soviet alliances and zones of influence; our strategic decisions are compatible with Chinese objectives as they erode these international alignments.

## 13.4 IMAGES OF INTERNATIONAL ACTORS

This section deals with Chinese images of several of the actors which we have determined to be members of the core international system. To illustrate the use of our communications data for analysis of the content of attention, we discuss parts of the images which the Chinese have of themselves, Japan, the United States, and the Soviet Union. The relevant data appear in Table III. For the following pairs of terms, each row in Table III contains the number of units of the first term in ratio to one unit of the second term: actions taken to actions received (row 1); opposition received from other actors to opposition given other actors (row 2);[6] support given other actors to support received from other actors (row 3); and involvement in cooperative interactions to involvement in conflictful interactions (row 4). To arrive at the scores in rows 2, 3, and 4, we used the frequency of actions on each side of the dichotomy times their intensity.

6.a. <u>China, relative to the other nations in Table III, engages in equal exchange relationships with the external environment</u>. In other words, the Chinese Communists receive an amount of opposition equal to

TABLE III

Images of Major Actors

| | A. C.P.R. | B. Japan | C. U.S.A. | D. U.S.S.R. |
|---|---|---|---|---|
| Attribute: | | | | |
| 1. Activity - Passivity Ratio | [illegible] | [illegible] | [illegible] | [illegible] |
| 2. System Opposition - Actor Opposition Ratio | [illegible] | [illegible] | [illegible] | [illegible] |
| 3. Actor Support - System Support Ratio | [illegible] | [illegible] | [illegible] | [illegible] |
| 4. Cooperation - Conflict Ratio | [illegible] | [illegible] | [illegible] | [illegible] |

that which they emit toward the international system (row [illegible]), and originate an amount of support approximately equal to that which they receive from the international system (row 3). This finding implies these hypotheses:

--- In total, Chinese actions toward the international system reciprocate the actions of the system toward China.

--- China is a "reasonable," "even-handed" and "firm" actor in the international system.

The preceding finding and hypotheses are general system statements and do not refer to Chinese relations with particular nations. However, they do have longrun implications for American national security planning. The first or balance hypothesis suggests that Chinese reactions to an American strategic decision will depend on the relationship which exists between China and the total system at that time and the effect of our decision on that relationship. Accordingly, we increase our ability to anticipate the Chinese response to the extent that we increase our understanding of: (i) the total set of China's relationships with its core international system; and (ii) the second-order effects of our decisions on China. For example, what effect does an American decisions to deploy ABM have on Japanese inputs to Communist China? The second hypothesis suggests that American planners should expect the Chinese to oppose U. S. decisions or those of other states which de facto deny China full equality in her core international system or require her to tolerate without response the actions of the international system. For example, we should expect the Chinese to reject proposals which would require China to accept permanent inferiority in nuclear arms; however, we should seriously consider the possibility that the Chinese would enter into and abide by international arrangements which would involve nuclear equality through force reduction on the part of the super-powers.

6.b. China, relative to the other states in Table III, engages in cooperative rather than conflictful relationships with the international system. Before exploring the implications of this finding, it seems useful to clarify the differences between the index on which it is based (row 4) and those discussed above in 6.a. (row 2 and 3). Rows [illegible] and [illegible]

deal with the direction in which actions flow (agent to target) for particular aspects of international relations. Thus row 2 gives us data on the flow of oppositional actions; row 3, of supportive actions. The index we use to arrive at finding 6.b. does not distinguish the direction of action flows. What it does do is compare the frequency and intensity of actions in which China and other nations, according to China, are supporting each other in ratio to the total set of actions in which China and other nations are opposing each other. Accordingly, the left-hand cell in row 4 gives us the units of cooperative interaction in which China is involved for one unit of conflictful interaction.

The Chinese see themselves as engaged primarily in cooperative interactions with the international system. We can reasonably assume that Americans see China as engaged primarily in conflictful interactions. There are two possible reasons for this discrepancy. One is that the Chinese are talking one game and acting out another. The other is that the Chinese are indeed more involved in cooperative than conflictful relationships, but that the actors in these relationships with China are in conflict with other nations (particularly the United States) and political movements. In section 13.5 of this report, we propose a research strategy to test the appropriateness of the first reason. Here it seems useful to explore some of the implications of the second. Let us restate a hypothesis based on it.

--- China does not directly enter into conflict with the international system but cooperates with states and groups which do engage in direct conflict.

If correct, this hypothesis has extremely important implications for U. S. policy: American strategies to counter Chinese policies should be aimed at the parties with which China cooperates rather than based on direct conflict with the People's Republic. For example, with regard to ABM deployment, the implication is that defense of the continental U. S. against Chinese attack is largely irrelevant to probable Chinese actions.

7.a. Japan, relative to the other nations in Table III, engage in favorably unequal exchange relationships with the external environment. Rows 2 and 3 reveal that the Chinese Communists believe that Japan receives less opposition from than it puts into the international system and gives out less support to than it receives from the international system. This finding implies that CCP elites assume the following about Japan:

--- Japanese decision-makers have been and will continue to try to be successful in relating "unfairly" to the international system.

To the extent that our hypothesis is correct, it becomes an important input to American analyses of Chinese Communist national security estimates. First, it implies that the Chinese Communists will react with some bitterness, perhaps envy, to American policies which they think contribute to Japan's welfare. (This would be a reaction analogous to that of some European states to American aid to post-World War II Germany. During World War II, of course, Japan was in a relationship to China analogous to German's relationship to, e.g., Holland or Norway.) Second, at the same time it implies that Chinese Communists will not anticipate that American increments to Japan's defense posture will ever be used to support American polities -- Japan always "gets more than it puts out." Third, it implies a low probability of any significant and lasting rapprochement between Japan and China. If the Chinese Communists feel that the Japanese are this clever in securing one-sided bargains, probably the CCP elites would never accept terms from Japan that the Japanese Government would find attractive.

7.b. Japan, relative to the United States and the Soviet Union, engages in co-operative rather than conflictful relationships with the international system. This finding depends on the data in the three right-hand cells of row 4. It implies that Chinese decision-makers will see Japan as less likely to be a primary party in a conflict than to support and receive the support of parties directly involved. Accordingly, American analysts should expect that the Chinese will evaluate changes in Japan's defense posture, not for their direct effects on Japanese military actions, but for their indirect effects on the ways in which Japan

helps proxies in conflicts. For example, with regard to ABM deployment in Japan, we would expect the Chinese to estimate what difference this would make in Japanese assistance for anti-Chinese groups in South and Southeast Asia.

8.a. The United States, relative to the other states in Table III, engages in unequal and unrewarding exchange relationships with the international system. The data in rows 2 and 3 show that the Chinese Communists think that the United States receives more hostility from the international system than it puts into it and that it originates more support for the international system than it receives from it. In other words, they feel that the "tide had turned against" the United States. Given the Communist Chinese ideology, this is not a particularly surprising finding. However, Americans still need to confront some very reasonable implications of this finding. First, the Chinese Communists will not believe that we can organize a "grand coalition" against them. This suggests that they will not find us as threatening to them as we would assume them to find us, given our formal alliance arrangements around China. Second, they will see changes in American strategic postures, e.g., ABM deployment, as temporary perturbations from our decline in international status. Accordingly, they will not feel that they have to make a major response.

8.b. The United States, relative to the other nations in Table III, engages in primarily conflictful rather than co-operative relationships with the international system. This finding derives from comparing the entries in row 4. This hypothesis is implied:

--- Since the Chinese Communists believe that conflict is endemic in any social system, this finding does not necessarily imply that they see the United States as uniquely engaged in conflict. It does imply that they see the United States as going out and fighting its own conflicts directly, as opposed to the proxy method which they and the Japanese use.

If this hypothesis is correct, we should expect that the Chinese Communists will expect us to oppose other parties directly rather than through proxies. Since China prefers to carry out conflict through

proxies (finding 6.b.), we should expect that the Chinese elites will try to channel our conflict behavior against third parties.

9.a. The Soviet Union, relative to the other states in Table III, acts on the external environment much more than it is the target of actions from the external environment. The index for this finding (row 1) is one of direction of action, without regard to its conflict-co-operation content. We hypothesize that what the Chinese Communists are seeing here is that:

--- The Soviet Union tries to shape the international system to an extent disproportionate to the international system's actions toward the Soviet Union, i.e., it is an unjustifiably interventionist power.

The implication here is that the Chinese Communists see Soviet activity in the international system as a property of, or dispositional to, the Soviet system, not as a response to situations in the international environment. Accordingly, we should not expect them to try to deal with the Soviets by moderating their or proxy behavior which is presumably provoking to the Soviets.

9.b. Although less than the United States, the Soviet Union engages more in conflictful than in co-operative relations with the international system (see row 4). Using the same logic as in finding 8.b. about the United States, we suggest that the Chinese see the Soviet Union as more likely to go out and fight its own conflicts directly than to use proxies. Again, since the Communist Chinese prefer to pursue conflict through proxies, they will try to channel Soviet conflictful activity toward third parties. Accordingly, we can expect them to examine and exploit American strategic decisions for their third party potential, i.e., to see whether strategic decisions we make can be manipulated to make us China's proxy in its handling of Soviet conflictful activity.

## 13.5 FUTURE WORK

The experimental pilot study we have been discussing seems sufficiently useful to warrant four research tasks.

First, the Chinese communications data already prepared for analysis should be analyzed for shorter time periods (day by day and week by week). Such analysis would indicate the extent to which and the manner in which Chinese communications are responsive to specific events or bound by fixed conceptions.[7] For example, the specific items we aggregated to get the mean Z scores in Table II can help establish the manner in which Chinese images of strategic actors vary or are constant. If we find interesting forms of variation, we can seek to what extent variation is explained (accounted for) by differences in international or domestic event climates.

Second, the strategic system findings derived from one domain of Chinese behavior (public communications) can be related to findings based on other sets of actions by China and towards China. Available data sets include: conflict behavior, trade, aid, diplomatic relations, and U. N. voting on Peking's admission.[8] This strategy should give us much more powerful and efficient indicators of China's present and future national security policy than we have now.

Third, we should expand our usable set of data on Chinese public communications for the 1950-64 period and extend it to more recent years. We can then arrive at more precise relationships, based on larger N's, and at explicit confidence levels through random sampling.

Fourth, if the third direction is taken, it seems useful to prepare for analysis the major body of restricted circulation Chinese communications available in this country, i.e., the People's Liberation Army "working papers."[9] We can compare these with our <u>People's Daily</u> material to establish the extent to which and the manner in which Chinese open messages differ or resemble those designed for at least one elite group. The comparison can begin to define the differences and similarities between the strategic perceptions which the Chinese elite shares with the public and those it recommends to and debates with the group which will implement its military strategies, i.e., the PLA officer corps.

## 13.6 REFERENCES


1. Davis B. Bobrow, "Chinese Response to Alternative U. S. Active and Passive Postures," in Davis B. Bobrow (ed.), Weapons System Decisions: Political and Psychological Perspectives on Continental Defense, New York: Frederick A. Praeger, in press.

2. Davis B. Bobrow, "Old Dragons in New Models," World Politics, Vol. XIX, No. 2, January, 1967, pp. 306-319.

3. Davis B. Bobrow, "Strategic Interaction," Annual Progress Report Civil Defense Research Project, March 1966 - March 1967, ORNL-4184-Part I, especially pages 145-155.

4. Robert Edward Mitchell, "The Use of Content Analysis for Explanatory Studies," Public Opinion Quarterly, Vol. XXXI, No. 2, Summer, 1967, pp. 230-241.

5. Norton Ginsburg, "On the Chinese Perception of a World Order," in Tang Tsou (ed.), China in Crisis, Vol. II, Chicago: University of Chicago Press, in press.

6. Ole R. Holsti and Robert C. North, "The History of Human Conflict," in Elton B. McNeil (ed.), The Nature of Human Conflict, Englewood Cliffs: Prentice-Hall, Inc., 1965, pp. 161-163.

7. Paul Smoker, A Time Series Analysis of Sino-Indian Relations, paper presented at the second International Peace Research Association Conference, Tallberg, Sweden, June 17-19, 1967.

8. Sources are: Jan F. Triska, Pattern and Level of Risk in Chinese Communist Foreign Policy-Making, 1949-1965, Stanford: Stanford University, September, 1967; Alexander Eckstein, Communist China's Economic Growth and Foreign Trade: Implications for U. S. Policy, New York: McGraw-Hill Book Co., 1966; A. M. Halpern (ed.), Policies Toward China: Views from Six Continents, New York: McGraw-Hill Book Co., 1965, Appendices A and B.

9. The source is: J. Chester Cheng (ed.), The Politics of the Chinese Red Army, Stanford, The Hoover Institution, 1966.

# 14. RESPONSES OF INFLUENTIALS TO NEGATIVE CONTINGENCIES*

Sue Berryman Bobrow

## 14.1 INTRODUCTION

As readers of last year's annual progress report[1] will recall, the object of this project is to:

- map quantitatively the system or meanings of appraisals
- which influential persons or groups assign to communications
- about the possibility of nuclear attack on the United States and alternative ways of handling this possibility
- so that their decisions about how to treat these communications can be statistically accounted for by their appraisals of them.

The project is now completely organized for collecting the data. This report is divided into sections that discuss these preparations: (1) compiling the universe of respondents; (2) locating biographic information on all members of the universe; (3) selecting alternative samples from the universe; (4) constructing, pre-testing, and revising the mail questionnaire; and (5) constructing, pre-testing, and revising the manual for the oral interview.

## 14.2 RESPONDENT UNIVERSE

In sampling theory a universe is a set of objects (in our case, groups of occupants of relevant positions within these), defined by rules of what is included and excluded. The universe from which we are selecting our sample is composed of three populations.

The first was compiled by R. E. Licklider[2] and includes individuals who have written in the unclassified literature on nuclear strategy and disarmament between January, 1946, and December, 1964, and are not

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*This report does not assume a professional social scientist audience, and our presentation and inclusion decisions reflect this.

employed fulltime and directly by the federal government. Licklider defined "nuclear strategy and disarmament" as nuclear weapons policy, thus excluded subjects such as civil-military relations, cost-effectiveness, government organization, military history, operations research, simulation, civil defense, intelligence, and much of the material labeled peace research or conflict theory, "unless work in these areas was directly and explicitly linked to nuclear weapons policy." (Licklider, p. 9) Individuals who had written on relevant topics were included in the sample if they had written: (1) one or more books, or (2) three or more articles in books, articles in periodicals, papers reproduced and circulated by a large number of formal organizations or institutes, or papers at a professional conference.[3] We added to Licklider's population in two ways. First, we extended it from December, 1964, to July, 1967, for individuals who had written on ballistic missile defense: since so much of the public debate on this system has occurred since Licklider's 1964 cut-off date, we felt we had to update the population for this one category. Except for lowering Licklider's inclusion criteria to one or more books or two or more articles, we used his same rules. Using his criteria, unmodified, we also compiled a special sub-population of all individuals who had written on civil defense from January, 1946, to July, 1967. Readers of last year's report will realize that this first population includes all individuals who have publically assumed responsibility for different aspects of nuclear weapons policy, rather than being allocated it by virtue of membership in particular organizations.

The second population is composed of occupants of relevant positions in relevant federal agencies, as both of these are listed in one source: United States Government Organization Manual, for the years 1945/46 through 1967/68.[4] First we judged which agencies have or have not had central or potential responsibility[5] for nuclear weapons policy and conflict management - for example, the U. S. Arms Control and Disarmament Agency, Department of Defense, Department of Air Force (see Appendix I for complete list). We included occupants of all of the following positions within the relevant agencies:

(1) positions of general executive responsibility for the agency's operations (e.g., Secretary of Defense, Director of the Office of Science and Technology); (2) positions of general executive responsibility for the agency's research and development programs (e.g., Director of Defense Research and Engineering, Director of Advanced Research Projects Agency); (3) positions of general executive responsibility for research and development of a major strategic system (e.g., Director of Project Defender); and (4) positions of general executive responsibility for the agency's planning (e.g., Chairman of the Policy Planning Council of the State Department). These positions were selected because they were assumed to be crucial either in the actual policy-making for the agency (type 1 positions) or in determining the policy alternatives available to the agency (type 2, 3, and 4 positions). In compiling this population, we had problems, not of missing, but of uncertain data: (1) the titles and organization of these four functions in the different agencies changed over time; (2) the functional descriptions for major positions in the Government Organization Manual were usually vague; and (3) the number of positions included in the Manual for each agency fluctuated over time. Although these problems did not affect compiling type 1 positions and affected type 2 positions only marginally, they did affect recording the type 3 and 4 positions. In the case of the type 2 and 3 positions, we were able to eliminate the first two data problems by checking our judgement against the Federal Organization for Scientific Activities, 1962 (NSF62-37), Organization of the Federal Government for Scientific Activities, 1956 (NSF56-17), and Advisory and Coordinating Mechanism for Research and Development 1956-57 (NSF57-13). These documents are all compiled by the National Science Foundation, and classify groups within the federal agencies according to whether they are not engaged in, partially engaged in, primarily engaged in, or part-time advisory groups for scientific activities. We were unable to eliminate the first two data problems for the type 4 position. We were unable to control the third data problem for any of the four position types.

The third population is composed of advisory groups (see Appendix II for complete list). We used four criteria in selecting these groups: (1) the majority of the group are not direct employees of the federal government; (2) the group is part-time or is specifically convened to prepare a study of a problem, short-term; (3) it is officially advisory to and financed by one of the agencies listed in Appendix I or relevant positions within the agency; and (4) it has primarily a scientific or analytic, rather than a political legitimation, function. The third criterion has particularly important implications, since it excludes privately-financed study groups (e.g., the national security part of the American at Mid-Century Series, financed by the Rockefeller Brothers Fund) and the government-financed groups which advise at state and local levels (e.g., the group which prepared what has become known as the Ruebhausen Report for the New York Governor's Office). We included members of these advisory groups for as long as each group has been in existence between January, 1946, and July, 1967. For example, the General Advisory Committee to the AEC has been in existence since 1946; the Defense Science Board, advisory to the Director of Defense Research and Engineering, was only convened in 1956; the Gaither Committee, Project East River, and the National Academy of Sciences Project Harbor Study were convened for specific studies and disbanded when they concluded their reports. The data problems for the advisory population are missing data problems, particularly for the very influential President's Science Advisory Committee panels on various aspects of nuclear weapons policy. We know the membership of some panels for the years when PSAC was considerably more active in nuclear weapons policy than it is today. However, we do not know the relationship of these panels to the total universe of relevant PSAC sub-committees.

## 14.3 BIOGRAPHIC DATA

After the universe had been compiled, we tried to prepare a card of biographic information for each member of three populations.[6]

An example of such a card is:

> Weinberg, A. M.
>
> WEINBERG, Alvin Martin, physicist; born Chgo., Apr. 20, 1915; s. J. L. and Emma (Levinson) W.; A.B., U. Chgo., 1935, A.M., 1936, Ph.D., 1939; Doctor of Laws, University of Chattanooga; married Margaret Despres, June 14, 1940; children—David, Richard. Research asso. math. biophysics U. Chgo., 1939-41, Metall. Lab., 1941-45; joined Oak Ridge (Tenn.) Nat. Lab., 1945, dir. physics div., 1947-48, research dir., 1948-55, dir. of the lab., 1955—. Mem. Pres.'s Sci. Adv. Com., 1960-62. Recipient Atoms for Peace award, 1960, E. O. Lawrence award, 1960. Mem. Nat. Acad. Scis. (physics sect.), Am. Nuclear Soc. (pres. 1959-60). Home: 111 Moylan Lane. Office: P.O. Box P, Oak Ridge, Tenn.

This process yielded our operational universe for the time our biographic sources were published, i.e., a universe of individuals who were alive, were not currently fulltime and direct employees of the federal government, and could be located. It also gave us the data to select our sample.

## 14.4 SELECTING THE SAMPLE

The exact size of the sample will depend on the resources available to the study. If more resources are available, we will work with a sample size of approximately 50 individuals. These individuals will be given both the mail questionnaire and an intensive, three-hour, taped personal interview. If we have fewer resources, we will work with a considerably larger sample (perhaps 1,000) and send out only the mail questionnaire. The mail questionnaire will allow us to describe how each individual perceives nuclear weapons problems and to compare his perceptions with those of other members of the sample. However, we have to depend on personal interview data to account for variations in these perceptions - i.e., to isolate the effects of personality, organizational membership, and sub-culture membership on individual perceptions. For example, assume that Dr. Y consistently sees international co-operation policies as more effective in managing nuclear threats to the nation than building up

assured destruction forces. What accounts for this preference? Is it personal habit, i.e., Dr. Y's customary way of handling all inter-personal and inter-group conflict? (This basis approach to human affairs could derive from being raised in a family that used this model successfully - for example, valued "enlightenment" as a way of resolving conflict and established an emotional atmosphere sufficiently positive to allow the family to absorb a negative episode as a temporary deviation from a positive norm.) Another personality explanation might be that Dr. Y feels ineffective as a human being in dealing with threats and can only try to "plead" his way out of a dangerous situation. Or are his preferences best accounted for by past organizational membership, e.g., by the fact that he was a member of the State Department, whose policies have traditionally been in the realm of international cooperation and communication? Or can his preferences be explained by his membership in a behavioral science sub-culture and consequently by his greater knowledge and imagination about what can be done with group and inter-group social institutions? These are obviously grossly different branches in explanation. They have grossly different implications for how one evaluates Dr. Y's recommendations and for the type of social engineering required to achieve certain policies.

Regardless of the final size of the sample, we intend to select a stratified sample. Very simply, a stratified sample is composed of sub-parts (strata), each of which is internally homogeneous with respect to some criterion. Operationally, the universe is divided into strata according to pre-determined criteria and a certain percent of individuals selected from each stratum. The criteria or partitions we are using are: (1) nature of responsibility (assumed; central - e.g., relevant members of the Federal Civil Defense Administration, National Academy of Sciences Advisory Committee on Civil Defense, Project Defender in ARPA, Office of Emergency Planning; potential); (2) discipline (relations between objects - e.g., physical sciences, engineering, operations research, mathematics; relations between people - e.g.,

behavioral sciences, law, history); (3) generation (individuals 25 years and older in August, 1945, individuals 24 years and younger in August, 1945); and (4) career (professional; military; civilian).

### 14.5 MAIL QUESTIONNAIRE

After constructing a useful draft of the questionnaire[7] we pre-tested it with 14 individuals at ORNL. Since the universe is a highly specialized one, we did not use the pre-test to devise statistically valid and independent items. We used it in the way one "de-bugs" a computer program - for example, determining which questions seemed redundant to respondents, which had confusing instructions (either in the sense of respondents not knowing what to do or doing something we did not want them to do), and which bored them. The pre-test group consisted of four social scientists and ten physical scientists and engineers. All fourteen had had research or administrative experiences relevant to nuclear weapons problems; and five had extensive knowledge about these problems. Four were in administrative positions, and one of these had some contact with the environment in which national security policy choices are made. Personalities of the group varied in terms of the balance of positive and negative emotion, the nature of the dominant emotions, and the willingness to express emotion.

The questionnaire was revised in terms of the pre-test results and the response categories formated for computer key-punching. The final questionnaire is 57 questions long, and 20 of these 57 are multi-item questions. Appendix III has examples of the questions.

### 14.6 PERSONAL INTERVIEW

As we indicated in the section on sampling, the point of the personal interview is to collect data that will let us account for variations in respondent reactions to nuclear weapons policies. The interview is based on an approximately 45 page interview manual and two

sets of pictures. The manual consists of seven batteries of questions, appropriate probes for each battery, and a brief statement for the interviewer of the theoretical point of each question or set of questions. The questions are all open-ended, i.e., the respondent is not restricted to a limited number of alternative responses between which he must choose. Before data of this kind can be analyzed, they have to be coded in terms of variables derived out of the interviews. This is a tedious process. However, we had to resort to open-ended questions for these reasons: (1) in some cases, we could not anticipate what the respondent might reply to a question - in other words, we could not compile a reasonably complete set of responses from which the subject could choose; and (2) in other cases, even if we could anticipate the set of "first-round" responses, we wanted to use the subject's initial response to inquire more deeply into the subject. This situation represents an increasingly complex branching tree and it is absurd and probably impossible to anticipate the details of the different turns the respondent might make.

The seven batteries of the questions are about: (1) the interaction between post-World War II nuclear weapons policy and the individual's professional activities (<u>history</u>); (2) what the individual <u>anticipates</u> will be the interaction between future nuclear weapons policy and his future professional activities; (3) the individual's appraisal of the social implications of the interaction between nuclear weapons policy and his profession; (4) the individual's religious or philosophical beliefs; (5) the deprivations which the individual has suffered; (6) a set of pictures which should indicate the subject's ability to express pleasure and positive emotion; and (7) a set of pictures of the human effects of nuclear weapons.

Excerpts from the personal interview manual are listed in Appendix IV.

## APPENDIX I: FEDERAL AGENCIES INCLUDED IN POPULATION #2*

Executive Office of the President

Department of State

Department of Defense

Department of the Navy

Department of the Air Force

Department of the Army

Defense Atomic Support Agency

U. S. Arms Control and Disarmament Agency

Atomic Energy Commission

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* This is a list of just first-order divisions in the Executive Branch, members of which were included in the population. For example, under the Executive Office of the President alone, we picked up position occupants in these groups: Office of Science and Technology, Office of Emergency Planning, Office of Defense Mobilization, Federal Civil Defense Administration, Office for Emergency Management, National Security Resources Board, Office of Civilian and Defense Mobilization, and White House Special Assistants for National Security Affairs and Scientific Affairs. Another example is the Department of Defense: Office of the Director of Defense Research and Engineering (and under this office, Weapons Systems Evaluation Group, Advanced Research Projects Agency), Office of the Assistant Secretary of Defense for International Security Affairs, Office of the Assistant Secretary of Defense for Systems Analysis, Office of the Assistant Secretary (comptroller) from 1961/62 - 1965/66, Joint Chiefs of Staff, and Staff to the Joint Chiefs.

# APPENDIX II: ADVISORY GROUPS INCLUDED IN POPULATION #3

Officials of the National Academy of Sciences - National Research Council

Officials of the National Academy of Engineering

Executive Board of the National Academy of Sciences - National Research Council

National Academy of Sciences Advisory Committee on Civil Defense

National Research Council Disaster Research Group

National Academy of Sciences-National Research Council Project Harbor Study

Project East River

Gaither Committee

Defense Science Board

Project Jason

Naval Research Advisory Committee

Air Force Scientific Advisory Board

Army Scientific Advisory Panel

Research and Development Board for the Department of Defense

Science Advisory Committee of the Office of Defense Mobilization

Advisory Council of the Office of Emergency Management

National Defense Research Committee of the Office of Emergency Management

President's Science Advisory Committee

President's Science Advisory Committee panels on offensive and defensive weapons systems

General Advisory Committee to the Atomic Energy Commission

Begin Deck [illegible]

______ (1-4)

## APPENDIX III: EXCERPTS FROM THE MAIL QUESTIONNAIRE

### Example 1

1. Below is a list of quotations, some of which you may recognize. They represent thoughts about the persistent problems of war and peace and about the security relationship of our nation to other nations. Please indicate how much you agree or disagree with each quotation by circling the appropriate number on the scale below it.

"We, born to freedom, and believing in freedom, are willing to fight to maintain freedom. We would rather die on our feet than live on our knees."

| | -3 | -2 | -1 | 0 | +1 | +2 | +3 |
|---|---|---|---|---|---|---|---|
| 5/1-7 | Disagree strongly | Disagree moderately | Disagree slightly | Equally agree and disagree | Agree slightly | Agree moderately | Agree strongly |

---

"Strength lies not in defense, but in attack."

| | -3 | -2 | -1 | 0 | +1 | +2 | +3 |
|---|---|---|---|---|---|---|---|
| 6/1-7 | Disagree strongly | | | | | | Agree strongly |

---

"In this country we have come to rely upon a comfortable time lag of fifty years or a century intervening between the perception that something ought to be done and a serious attempt to do it."

| | -3 | -2 | -1 | 0 | +1 | +2 | +3 |
|---|---|---|---|---|---|---|---|
| 7/1-7 | Disagree strongly | | | | | | Agree strongly |

---

"There never was a good war or a bad peace."

| | -3 | -2 | -1 | 0 | +1 | +2 | +3 |
|---|---|---|---|---|---|---|---|
| 8/1-7 | Disagree strongly | | | | | | Agree strongly |

---

"Human history becomes more and more a race between education and catastrophe."

| | -3 | -2 | -1 | 0 | +1 | +2 | +3 |
|---|---|---|---|---|---|---|---|
| 9/1-7 | Disagree strongly | | | | | | Agree strongly |

---

"The only limit to our realization of tomorrow will be our doubts of today."

| | -3 | -2 | -1 | 0 | +1 | +2 | +3 |
|---|---|---|---|---|---|---|---|
| 10/1-7 | Disagree strongly | | | | | | Agree strongly |

---

(continued on next page)

1. (cont.)

"There has never been any country at every moment so virtuous and so wise that it has not sometimes needed to be saved from itself."

| | -3 | -2 | -1 | 0 | +1 | +2 | +3 |
|---|---|---|---|---|---|---|---|
| 11/1-7 | Disagree strongly | Disagree moderately | Disagree slightly | Equally agree and disagree | Agree slightly | Agree moderately | Agree strongly |

"Allegiance requires an enemy."

| | -3 | -2 | -1 | 0 | +1 | +2 | +3 |
|---|---|---|---|---|---|---|---|
| 12/1-7 | Disagree strongly | | | | | | Agree strongly |

"Mankind has grown strong in eternal struggles, and it will only perish through eternal peace."

| | -3 | -2 | -1 | 0 | +1 | +2 | +3 |
|---|---|---|---|---|---|---|---|
| 13/1-7 | Disagree strongly | | | | | | Agree strongly |

"Perfectionism, no less than militant enemies, may obstruct the paths to international peace."

| | -3 | -2 | -1 | 0 | +1 | +2 | +3 |
|---|---|---|---|---|---|---|---|
| 14/1-7 | Disagree strongly | | | | | | Agree strongly |

"When you see someone poised to strike, you do not wait until he has struck before you crush him."

| | -3 | -2 | -1 | 0 | +1 | +2 | +3 |
|---|---|---|---|---|---|---|---|
| 15/1-7 | Disagree strongly | | | | | | Agree strongly |

"The dangers of the world are extremely grave, and to achieve even a tolerable amount of safety and security takes ceaseless effort and concern."

| | -3 | -2 | -1 | 0 | +1 | +2 | +3 |
|---|---|---|---|---|---|---|---|
| 16/1-7 | Disagree strongly | | | | | | Agree strongly |

"The more extortions thus cheerfully accepted, the more unjustified does it seem to people finally to set about defending themselves."

| | -3 | -2 | -1 | 0 | +1 | +2 | +3 |
|---|---|---|---|---|---|---|---|
| 17/1-7 | Disagree strongly | | | | | | Agree strongly |

NOTE: THERE ARE 2 MORE ITEMS TO THIS QUESTION WHICH ARE NOT INCLUDED HERE.

Example 2

6. For just a moment, try to imagine your personal situation at the time of a nuclear attack on the United States. As you think about this, are there any possible circumstances that particularly frighten you, or that you particularly dread? This is a question not about what you think are your most <u>probable</u> personal circumstances, but about what you are most <u>afraid</u> they will be. As you can see below, people like you have answered this question in various ways. By circling a number to the right of each quote, could you please indicate how much you share that person's reaction?

| | | |
|---|---|---|
| 65/1-7 | "What I'm most afraid of is getting trapped or crushed by a frightened crowd of people." | 1 2 3 4 5 6 7<br>Don't share at all ... Share greatly |
| 66/1-7 | "This may sound funny to you, but I suppose what frightens me the most is what I would be forced to realize about human beings and what they can do to each other." | 1 2 3 4 5 6 7<br>Don't share at all ... Share greatly |
| 67/1-7 | "Although I may be afraid of some personal circumstance, the important thing to me about a nuclear attack is not fear but the problems that have to be solved." | 1 2 3 4 5 6 7<br>Don't share at all ... Share greatly |
| 68/1-7 | "When I think about this, what scares me the most is the fear, maybe the <u>terror</u> I think I'm going to feel at that time." | 1 2 3 4 5 6 7<br>Don't share at all ... Share greatly |
| 69/1-7 | "The thing I dread is a feeling of helplessness, of ineffectiveness." | 1 2 3 4 5 6 7<br>Don't share at all ... Share greatly |
| 70/1-7 | "By far the most frightening possibility to me is not being able to get to the people I love -- being cut off from them." | 1 2 3 4 5 6 7<br>Don't share at all ... Share greatly |
| 71/1-7 | "What scares me is the possibility of being caught in a zone where I won't be killed, but will be badly injured, or trapped in debris or surrounded by fire." | 1 2 3 4 5 6 7<br>Don't share at all ... Share greatly |

(continued on next page)

Example
(cont.)

| | Quote | Scale |
|---|---|---|
| , 1- | "What frightens me is not having enough warning time to get anyplace that might be safe." | 1 2 3 4 5 6 — Don't share at all … Share greatly |
| 3/1- | "What I dread is having to face up to what this is going to mean for the children -- I don't mean just my own children. These are the ones who still have so much life ahead of them." | 1 2 3 4 5 6 7 — Don't share at all … Share greatly |

-- /blank There may be no quote here that describes what frightens you the most -- for example, its being dark or your being asleep at the time of attack. If there is no appropriate quote, would you please write one that would describe your reaction? ______________________________

______________________________

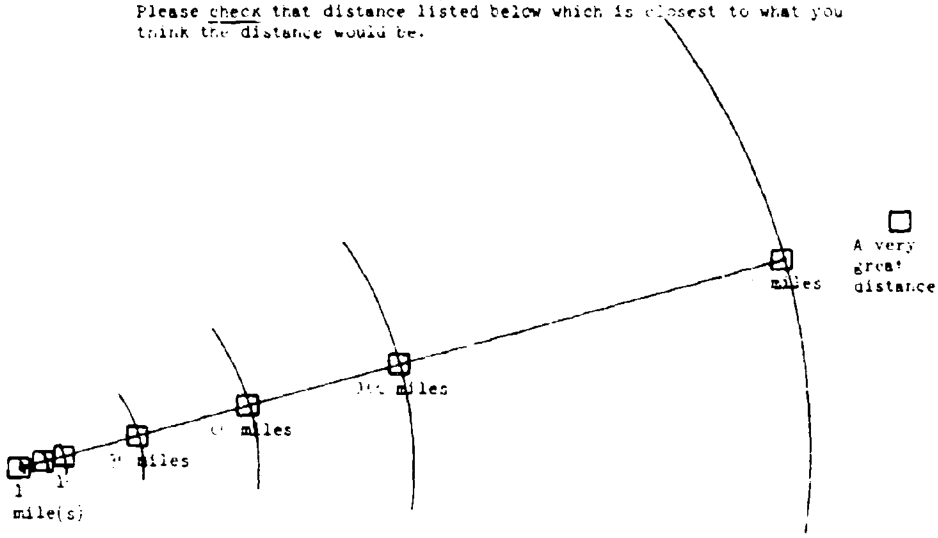
______________________________

______________________________

Example 3

If the United States were to be attacked with nuclear weapons for the reason you rated most likely in question -, how much distance do you think there would be between you and the detonation closest to you? Please check that distance listed below which is closest to what you think the distance would be.

, 1-



Example 4

9. About how much time do you think there is between you and a nuclear attack on the United States? Please check the box below that represents the most probable amount of time you think you have.

7/1-8

- Less than 5 years
- 5 years
- Soon in your lifetime -- about 10 years
- At the end of your natural lifetime
- In your children's, but not your lifetime
- In your grandchildren's, but not your children's lifetimes
- In your great grandchildren's, but not your grandchildren's lifetimes
- Will never happen

Example 5

79-80/04
Begin Deck 05

(1-4)

19. Below are 10 alternative ways of handling the threat of nuclear attack on this country and 7 pairs of adjectives for describing these alternatives. By using the numbers which preface the 10 alternatives, how would you relate them to each other in terms of each descriptive pair? You can put as many numbers as you want into a cell (or "box") within the row. You can also leave a cell empty if you wish.

For example, suppose you were rating the 10 alternatives according to the third pair of adjectives -- "Rash-Cautious." You might end up arranging the 10 alternatives in this pattern:

| | Very | Moderately | Slightly | Equally | Slightly | Moderately | Very | |
|---|---|---|---|---|---|---|---|---|
| Rash | 2, 8 | | 10, 4, 3 | 5, 6, 7 | 1 | 9 | | Cautious |

This would mean, for example, that you think #2 (pre-emptive attack) and #8 (unilateral disarmament by the U.S.) are very rash, equally so, and more rash than any of the other alternatives. You do not think any of the alternatives are very cautious. Et cetera.

5-10/1-7 (1) civil defense
11-16/1-7 (2) pre-emptive attack posture
17-22/1-7 (3) exchange of hostages
23-28/1-7 (4) inspected, multi-lateral arms control and disarmament
29-34/1-7 (5) "people to people" programs
35-40/1-7 (6) active homeland defense
41-46/1-7 (7) developing areas of inter-dependence
47-52/1-7 (8) unilateral disarmament by the U.S.
53-58/1-7 (9) armed deterrence
59-64/1-7

| | Very | Moderately | Slightly | Equally | Slightly | Moderately | Very | |
|---|---|---|---|---|---|---|---|---|
| Moral | | | | | | | | Immoral |
| Dull | | | | | | | | Challenging |
| Rash | | | | | | | | Cautious |
| Difficult | | | | | | | | Easy |
| Immediate Payoff | | | | | | | | Delayed payoff |
| Desirable | | | | | | | | Undesirable |

## APPENDIX IV: EXCERPTS FROM THE PERSONAL INTERVIEW

### Example 1

(Note: Questions in Part I are about aspects of the individual's work on a selected national security problem, preferably a continental defense problem if he ever worked extensively in the area.)

### Part I

B4. (Interviewer: listen for self-reports of controversy in which subject was involved when he worked on the problem. If he mentions any instances of interpersonal conflict, use the probes listed below. If he has not mentioned any such instances, ask:

When you were working on (problem subject selected), did you run into any situation where - initially, at least - others seriously disagreed with you about how something should be done?

If subject says yes, get a description of these situations and go to the following probes. If he says no, drop the subject until item ____.)

Probes:

- Who disagreed with you? Was this person (these persons) a superior of yours? A subordinate? (i.e., determine power relationships between contestants)

- What was your view on this question? What was his (theirs)? (Probe particularly for: problem-solving strategy if subject defines it as a technical problem; political strategy if subject defines it as a political problem.)

- What in his (their) argument were you objecting to? What was he (were they) objecting to in yours? (Probe particularly for: problem-solving strategy if subject defines the conflict as technical; political strategy if the subject defines the conflict as political; confidence in self; confidence in others; confidence in events/processes; ego-defensiveness; rage.)

- How did this conflict get resolved? (Probe particularly for political strategy; rage; hostility; love; handling of power.)

- Do you still feel he was (they were) misguided in his (their) stance? (Probe particularly for: dogmatism; confidence in others; ego-defensiveness; hostility; love.)

- Did you change your views at all as a result of the conflict? If so, how? (Probe particularly for: dogmatism; confidence in self; ego-defensiveness.)

- If this conflict had been resolved in a way very disturbing to you, what do you think you would have done? (Probe particularly for marketability, i.e., subject's perceived freedom of professional movement and subject's willingness to exercise whatever freedom he thinks he has.)

Example 1 (cont.)

- Have you evolved any general rules or procedures for handling conflicts or disagreements like this? (Probe for: political strategy; handling of power.)

## Example 2

(Note: This example is taken from a battery of questions, all of which follow from this initial question: You have probably had young men and women come to you for advice about their future careers. If a young man came to you and asked you about going into (strategic analysis, if that is the respondent's field; or, the national security side of respondent's field), what do you think you would say to him? Would you encourage him?)

Part III

A3. (Interviewer: respondent may have talked in some detail about his preferred allocation of resources in his discussion of the last question. If not, ask:)

As we both know, the basis on which funds are allocated can vary, according to . . . oh, the defense problem being considered or the organization within which you work. In advising this young man, what fund allocation arrangement would you encourage him to find, if he can?

On this card we have listed different funding arrangements. To what extent would you advise him to seek each of these? (Hand respondent Card A.)

(Interviewer: this question is the key one for member type.)

CARD A

1. "Resources should be allocated on the basis of the record of the organizations and departments which seek them."

2. "The best thing is to find the most crucial problem and then really pour the money into it!"

3. "It's best to give funds to the really bright people, because no matter what they do, they'll do something good for you."

4. "Even if the work is good, it's just not worth funding controversial stuff."

5. "Resources are scarce. Accordingly, the responsible course is to think about the whole range of domestic and defense benefits which different uses promise to yield, and to fund on that basis."

## Example 3

Part III

C. The members of most professions are exposed to impressions which persons outside of their profession have of them. For example, psychiatrists are sometimes told that they went into psychiatry because they themselves are sick. Since President Eisenhower's farewell warning to the American people about the misuse of power by military, armaments industry, and scientific-technological elite, we've heard many different views of persons concerned with strategic and weapons analysis. You might look at some of the more common ones on this card. (Hand respondent Card C.)

CARD C

1. "In the nuclear era, it is an obligation to work on the vital problems of national security. The men who do so are socially responsible."

2. "People go into defense research and analysis for the buck. If there's money in the project, whatever it is, they'll do it."

3. "These people are intent on advancing the frontiers of knowledge and are making responsible use of opportunities to do so."

4. "They are callous about human suffering and are sometimes even attracted to mass destruction."

5. "At best they are Eichmanns - they follow orders without considering the consequences of their work."

(After respondent has a chance to read the card, ask:) Do you think any views on that card are valid?

(If respondent says none of these, ask:) In what ways do you think (1, 2, 3, 4, 5) is invalid, or incorrect? (Interviewer: as he talks about each item on the card, ask:) How widely shared do you think this view is? What kinds of people do you think would voice such a view?

(If respondent says yes, ask:) Which ones do you think are valid? Why do you think so? How widely shared do you think each of them is? What kinds of people make the statements you selected as correct? (Interviewer: unless respondent has selected all five items on the card, ask:) You didn't mention # . Do you think that remark (those remarks) is (are) not valid? (If yes, ask:) Why aren't t[illegible] Do you think they are widely shared? What kinds of people ma[illegible] remarks like these?

(Interviewer: use the respondent's reactions to the items on Card C for getting at the respondent's: primary moral orientation; ego-defensiveness; anxiety; hostility; guilt; rage; love; dogmatism; moral confidence in self, others, events/processes.)

(Interviewer: if you can't get the respondent to react to the card, you might try one of the following probes to get at the variables just listed:)

Other defense experts with whom we have talked have told us that their old classmates and children have attacked them for their work. Has this ever happened to you?

Some physical scientists say they will only work in "peace labs" and some social scientists describe their work as "peace research." What does the use of these labels signify to you? Would you describe your work in terms anything like these?

Example 4

To the interviewer: the basic variables we are trying to measure with Form A and Form B of the religious/philosophical belief questions are these:

1. confidence in the self: the morality of one's action, the predictability of one's action, and the effectiveness of one's action.

2. confidence in others: the morality of others' actions; the predictability of others' actions; and the effectiveness of others' actions.

3. confidence in events, processes, states: morality of system outputs (good, bad, neutral); predictability of system outputs; alterability of system outputs.

Use Form A for those who on the mail questionnaire felt that religion played a slight to great part in their lives (i.e., if they circled 2, 3, 4, or 5 in question 35b). Use Form B for those who marked 1 in question 35b (i.e., religion plays no part in their lives).

FORM B

I noticed on your mail questionnaire that you do not feel that religion plays a part in your life. However, you probably have some philosophical or ethical views about the nature of the world, of man, and so forth.

1. For example, how do you feel about man's basic nature? Do you think that man is basically evil in nature?

YES (If P does) Do you think he is then capable of becoming good, or do you think that he is evil throughout his life on earth and can only try to keep himself from acting as his nature would dictate?

NO (If P does not think that man's nature is basically evil.) Do you think he is basically good in nature, and simply needs help in realizing his basic nature? Or do you feel that man's nature is neutral -- in other words, that he is capable of both good and evil, depending on the circumstances? (If P thinks that man's nature is basically neutral, might try to probe for nature of circumstances that "cause" a person to act one way or the other.)

2. What do you feel about the world? Do you think the world is basically a bad place?

YES (If he does think the world is basically bad) Is it predictably bad, or just sometimes bad? Are there any ways we can affect it and make it better?

NO (If he does not think the world is basically bad) Is it basically good? Or just neutral?

GOOD (thinks world basically good) What causes things to happen that are not good? Are there ways of affecting these causes?

NEUTRAL (thinks world basically neutral) What do you mean by neutral? Do you mean that things happen in the world that are sometimes good and sometimes bad?

YES What is responsible for the good things? The bad ones? What can we people do to assure the good ones? Change the bad ones?

NO Do you mean that things that happen in the world are not to be explained or described in "moral" terms, like "good" and "bad"?

3. Do you think that death ends everything for a person?

NO (If P does not think death ends everything) What do you think happens to a person after death? Would people who had tried to live a good life be rewarded in some way? Would people who had led a bad life be punished?

YES (If P thinks death ends everything) Do you think people, after their deaths, "continue" in any way? (probe for various "immortality" ideas -- children, nature, man's works, e.g., court decisions for a judge)

4. Do you think that the world will come to an end someday?

YES (If P does think it will) How do you think this will happen? Will it be apocalyptic in nature, in other words, sudden, violent?

5. Do you think that suffering is inevitable?

YES (If P thinks it is inevitable) For all people? Why is it inevitable? Is there anything we can do to affect it? Are just some kinds of suffering inevitable?

NO (If P does not think suffering is inevitable) In what ways is it not inevitable?

[Instruction to interviewer: Question 6 is really a transition question between the religious-philosophical beliefs and suffering history. It might be asked elsewhere to better effect, but I don't think it should be asked in the course of eliciting the suffering history. This question attempts to measure the respondent's compassion for human beings outside of those for whom we would most expect him to have compassion.]

6. While we are on the philosophical question of suffering -- when you see a human being who has been hurt, what is your very first impulse? I don't mean, what you actually end up doing about it, but what is the very first thing you want to do about it?

FALLBACK PROBES FOR 6 (Interviewer: use the following probes only if you aren't getting any response.)

Well, for example, is your first reaction to get competent medical help?

Do you want to turn away?

Do you want to run over to the person, although you aren't sure what you would do once you got there?

Do you feel you shouldn't interfere?

**FALLBACK QUESTION FOR 6**

(Interviewer: if you aren't happy with the responses to the last question, you might try the next one.)

Have you ever run over an animal in the road?

**YES** (If P has) How did you feel? Did this bother you particularly, or did you feel that there was nothing you could have done to prevent this without endangering other people's lives?

**NO** (If P hasn't) When you see an animal that has been run over in the road, how do you feel? (If P feels badly) Are you ashamed of this feeling in any way? (If P does not feel badly) Why is this?

## 14.7 REFERENCES

1. Annual Progress Report, Civil Defense Research Project, March 1966-March 1967, ORNL-4184, Part I, Oak Ridge National Laboratory, p. 92.

2. Dr. R. E. Licklider used this population in his Ph.D. dissertation, "The Private Nuclear Strategists," presented to the Department of Political Science, Yale University, in January, 1968. We would like to thank him for his generosity in sharing his population with us.

3. Dr. Licklider solicited publication lists from an enormous number of academic, non-profit, and profit research organizations and "cause" organizations (e.g., SANE, Physicians for Social Responsibility, Women's International League for Peace and Freedom).

4. The United States Government Organization Manual is revised annually by the Office of the Federal Register, National Archives and Records Service, General Services Administration in Washington, D. C.

5. By having central responsibility, we mean that one of the main points of the agency is to work on that problem. For example, ARPA has had a central responsibility for the ballistic missile defense problem. By "having potential responsibility" for a particular solution, we mean that an agency has been allocated a central responsibility within which that solution can be expected to fall. This does not mean that the agency will necessarily decide to implement their central responsibility by pursuing that solution. For example, the Defense Department has been allocated a central responsibility for the nation's defense, but they can implement this in a variety of ways. Readers of last year's report will notice that we have omitted agencies which have peripheral national security responsibilities, such as the Department of Agriculture. We made this decision because peripherally responsible agencies are not central in deciding what national security policies the country should pursue. The relevant questions for agencies of this sort is why and how they implement or do not implement aspects of the total responsibility which are assigned to them after the basic policy decisions are made.

6. Our primary biographic sources were: Who Was Who, Who's Who, and American Men of Science.

7. K. E. Davis of the Psychology Department of the University of Colorado, P. T. Knoepfler, psychiatrist, of Salt Lake City, and D. B. Bobrow and T. H. Atkinson of ORNL, helped particularly in working out the pre-test version of the questionnaire. D. B. Bobrow, T. H. Atkinson, and N. E. Cutler helped particularly with the final version of the questionnaire.

## 15. PUBLIC RESPONSES DURING AN INTERNATIONAL CRISIS

Tom Atkinson

Investigations of public opinion toward various national and personal civil defense postures have generally been of two types: (a) analyses of single samples of respondents to determine the extent of support for these postures and/or the correlates of that support, and (b) trend studies comparing the response frequencies from several samples drawn at different times. In this latter case, the samples are usually drawn at widely separated (at least one year) points in time (Nehnevajsa, 1964, 1966, 1967; Coleman 1967). While both types of studies have been helpful in establishing general propositions about civil defense attitudes and behavior, they have failed to cast much light on a central question facing policy formulators: "What steps can the American public be expected to take to protect itself during an international crisis which may escalate into a nuclear war?" This report is an attempt to answer that question through an analysis of public opinion changes during the confrontation between the United States and the Soviet Union over Berlin in 1961.

The importance of understanding public reactions during crisis periods is magnified by the following factors:

(1) civilian protection in case of attack is currently largely dependent on the public's own capacity to protect itself since municipal, state, and federal civil defense programs are small.

(2) acceptance by the general public of civil defense precautionary measures as an ongoing part of their lives has been minimal; however, widespread acceptance of protective measures might be acquired during a crisis but before an attack;

(3) it is generally agreed, at lease among planners, that a nuclear attack will result from crisis escalation rather than be a sneak attack.

These considerations indicate the necessity of an adequate understanding

of public responses in crisis situations in both pre- and post-attack planning.

The 1961 Berlin confrontation was chosen as the case for analysis for the following reasons:

(1) It was a direct confrontation between the Soviet Union and the United States with both sides possessing, or believed to be possessing, massive delivery and destruction capabilities.

(2) The confrontation itself extended over a period of approximately six months (June through November) allowing adequate time for public reaction.

(3) The citizen was primarily responsible for his own and his family protection in case of attack.

(4) During this period, the Kennedy administration placed a heavy emphasis on civil defense in general and specifically on private protective measures such as home shelters and stock-piling food.

The June-November period of 1961 has been shown to be an extremely high tension period by both Withey (1962) and Popkin (1966). With public attention focused on the Berlin Crisis and on private civil defense measures, that period provides an excellent opportunity for the analysis of changes in civil defense attitudes and behavior.

## 15.1 METHODOLOGY

The lack of studies relevant to this question has been the result of a lack of sufficient data for the appropriate analysis. Most investigators assume that in order to conduct a study of change over time a group of respondents must be selected and observed at various points during the time span, a technique known as a panel study. Such studies are costly to carry out and involve some serious methodological shortcomings; consequently, they have been avoided. There is, however, another approach which does not involve the tracking of single individuals. In place of single individuals, the investigator measures or tracks groups for types of respondents over time. Instead of asking

the same question to the same individuals repeatedly, he asked the same question to different individuals sharing certain characteristics at different points in time. This technique is similar to that used by Pool, Abelson, and Popkin (1964) and, for convenience will be referred to as the comparable group method.

If the requirement of identical respondents is dropped in favor of comparable groups, it becomes possible to make use of public opinion survey data to study attitude and behavior change. The American Institute of Public Opinion (AIPO), also known as the Gallup Poll, conducts a national opinion survey each month. During the June-November, 1961, period, their surveys included questions about U. S. policy in Berlin, expectations of war, and civil defense precautions taken by the responden's, in addition to their usual political preference and demographic questions. The demographic variables can be used to group the respondents in such a way as to form comparable groups and the repeated expectation of war and civil defense behavior questions allow the derivation of an index of change on those variables.

Since our interest is in the nature of the response of the population, in general, and certain groups within that population in particular, the grouping of respondents within each sample should be made on the basis of a variable which has been shown to be related to this reaction process. Studies by Smith (1961), Rosi (1965), Hero (1966), and Caspary (1967) have shown that education is associated with differences in reaction to international events. The differences in attitude change found by each investigator were not differences in the direction of the change but in the extremity of the change and the speed with which it followed the event. For example, if the event was a new Soviet proposal for atmospheric test suspension, the high and low education groups would not differ in that one would become more pro-test suspension and the other less so but in that the high education group would evidence an attitude change more quickly and more noticeably than the low education group.

The factors responsible for the association of education and responsivity to international events have not been isolated in most

studies because measures of these intervening factors were not present. The psychological literature suggests three factors which are highly correlated with education and may be responsible for differential responsivity:

(1) Education has been shown to be positively correlated with awareness of, interest in, and knowledge about international affairs. Educational differences in reaction could be due to differences in exposure to the events.

(2) Education is negatively correlated with dogmatism or receptivity to information differing from one's present conception of the situation or object. Education may be correlated with response differences because the lower the education the greater the tendency to reject information inconsistent with one's present attitude.

(3) Education is positively correlated with cognitive complexity or the ability to understand and integrate the implications of new information. The relationship between education and responsiveness may be due to an inability on the part of the lower education respondents to understand the implications of the new information.

All three factors undoubtly contribute to the association of education and responsiveness. The contribution of each is unknown but the influence of educational differences is established.

To summarize, in order to discover the nature of public reactions to international crisis, the data from six public opinion polls conducted monthly during the Berlin Crisis of 1961 will be subdivided on the basis of the educational level of the respondents and the responses of those education groups to questions about the possibility of war and civil defense postures will be traced during that six month period.

## 15.2 HYPOTHESES

The hypotheses can be divided into two sets - the first dealing with the nature of the reaction process and the second concerning the

relationship between education, expectation of war, and civil defense behavior.

(1) Reaction hypotheses

(a) Speed of reaction. Smith (1961), Rosi (1965), and Caspary (1967) have found that the higher the educational level, the greater the sensitivity to incoming information about international events. In all three studies, high education groups evidenced a more rapid change in attitude following major events than low education groups. This finding is consistent with psychological research on the "two-step flow of communication" (Lazarsfeld, Berelson, and Gaudet, 1948; Katz, 1957; Katz and Lazarsfeld, 1955; Klapper, 1961). This concept refers to the process by which information is disseminated through a population. Novel information is first picked up from various media by "opinion leaders" and then passed through interpersonal contacts to others in the population. One characteristic of "opinion leaders" is that they are better educated than those they pass the information to. This leads us to the first hypothesis: The higher the education, the more quickly the group will respond to the increasing tension of the Berlin Crisis. This should be true for judgements of the possibility of war and the tendency to adopt civil defense measures as protection from such dangers.

(b) Direction of change. This line of reasoning also leads to the expectation that the direction of change will be the same regardless of educational level. If the information must be transmitted through a group, it will be repeated in a manner somewhat biased by the orientation of the transmitting agent; consequently, the direction of the change should be similiar to that of the first group. Our second hypothesis is: There should be no difference in the shape of the opinion and behavior change curves of the education groups other than that resulting from the time lag specified in Hypothesis la.

(c) Extremity of response. Rosi (1965) found that the high education group incurred greater opinion shifts toward suspension of testing than did the low education group. Our hypothesis will reflect his finding: With original attitude level compensated for, the

higher the educational level, the greater the extremity of opinion and behavior changes.

(d) Longevity of change. Hero (1966) has found that greater stability in attitudes toward the U.N. existed among high education groups than among low education groups. Smith (1961) has also found the same relationship in attitudes toward other international affairs issues. Our hypothesis is: Changes in opinion and behavior will be longer lived the higher the education level of the group.

(2) Variable relationship hypotheses

(a) Expectation of war and civil defense behavior. Although several studies comparing home owners who had built shelters with those who had not have indicated that there are no differences in their perceived immence of war (Berrien, 1963; Ekman, Cohen, Moos, Schlesinger, and Stone, 1963) analyses of more representative samples have indicated that expectation of nuclear war is positively correlated with a tendency to adopt civil defense measures (Rose, 1963; Withey, 1961). Our hypothesis is: Increases in the perceived likelihood of nuclear war will be associated with increases in the proportion of the population engaging in civil defense oriented behavior.

(b) Education and expectation of war. Education has often been found to be negatively correlated with perceived probability of war (Smith, 1961; Scott, 1965; Farris, 1960). Our hypothesis will be the same: Regardless of the level of crisis, the higher the educational level, the lower the expectation of war.

(c) Education and civil defense behavior. Education is generally found to be positively correlated with civil defense behavior (Withey, 1961; Mast, 1966; Coleman, 1967; Berrien, Schulman and Amarel, 1963; Rose, 1963). Again, our hypothesis is similiar: Regardless of crisis level, the higher the education level, the higher the incidence of civil defense behavior.

(d) Expectation of war, civil defense behavior and education. Hero (1959) reviews a number of studies which indicate that the higher the education level, the greater the consistency between attitude and action. Applied to our investigation, this association leads to the following

hypothesis: The correlation between expectation of war and civil defense behavior will be stronger, the higher the education level.

## 15.3 OPERATIONALIZATION

The hypotheses were tested by analysizing the data from six national public opinion surveys conducted by the American Institute for Public Opinion from June through November of 1961. A survey was conducted at about the same time during each of those months. Each survey involved the administration of a questionnaire to approximately three thousand individuals.

Each questionnaire consisted of approximately twenty-five items. Of those three types of items were of interest in our primary analysis:

(1) Surveys conducted in June, July, September, and October included a war expectation question usually "Do you think the Berlin conflict will lead to a fighting war?" The respondent could answer affirmitively, negatively, or indicate that he did not know whether it would or would not. For our purposes, a "Yes" was scored as 1, a "Don't Know" as .5, and a "No" as 0. A group's score was the average of its members with high scores indicating high war expectation. This question was asked to all those respondents who stated that they were aware of the U. S. - Soviet confrontation over Berlin.

(2) Surveys conducted in July, August, September, October, and November included at least one question about steps the person had taken to protect himself and/or his family. Usually there was one question about structural modifications of the home and another about stockpiling food in case of attack. The latter question was chosen as the civil defense behavior index because:

   (a) it did not discriminate against those who could not afford to modify their home;

   (b) it did not discriminate against those who did not own their home;

(c) stocking food can be much quickly done and hence is more likely to be sensitive index of change, and;

(d) so few people (usually under 2%) modify their home that measurement error too easily masks any fluctuations.

This question could only be answered "Yes" or "No", a "Yes" being scored as 1 and a "No" as 0. The group score represents the percent who said they had stored food. The higher the score, the greater the number engaging in that civil defense behavior. This question was asked of all respondents.

(3) Finally, each respondent was asked to indicate the extent of his formal education. For the purposes of this study, all those who had received only a grade school education or less constituted the lowest education category, those receiving some high school training but no college experience formed the middle category and those who had some college work were in the highest category. This division resulted in about 37% of the sample falling into the lowest category, 46% into the middle category, and 17% into the highest category.

## 15.4 RESULTS

Since the hypotheses about both the structure of change and the relationships between the different variables can be tested by reference to the same set of graphs, those graphs will be presented and their implications will be explored.

Figure 1 represents the scores for the total samples on the expectation of war and civil defense variables.

Figure 2 represents the scores for the lowest education group on the expectation of war and civil defense variables.

Figure 3 represents the scores for the middle education group on the expectation of war and civil defense variables.

Figure 4 represents the scores for the highest education group on the expectation of war and civil defense variables.

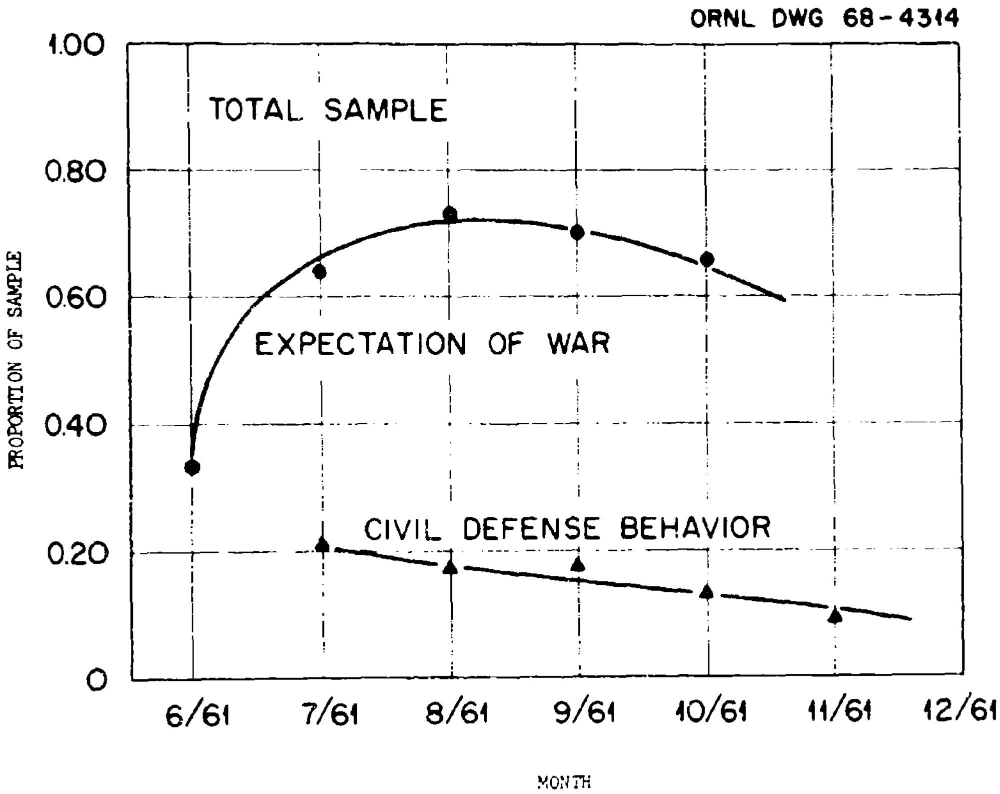



Fig. 15.1. Proportion of National Samples Expecting War and Engaging in Civil Defense Behavior During 1961 Berlin Crisis.

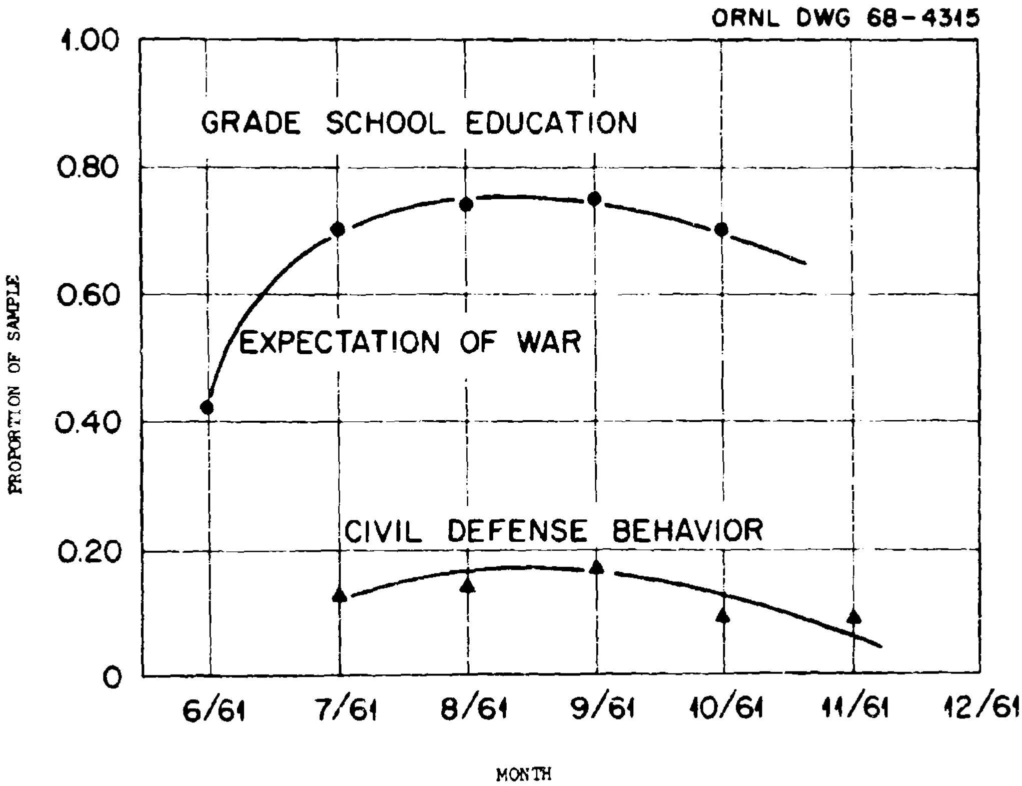



Fig. 15.2. Proportion of Low Education Respondents Expecting War and Engaging in Civil Defense Behavior During 1961 Berlin Crisis.

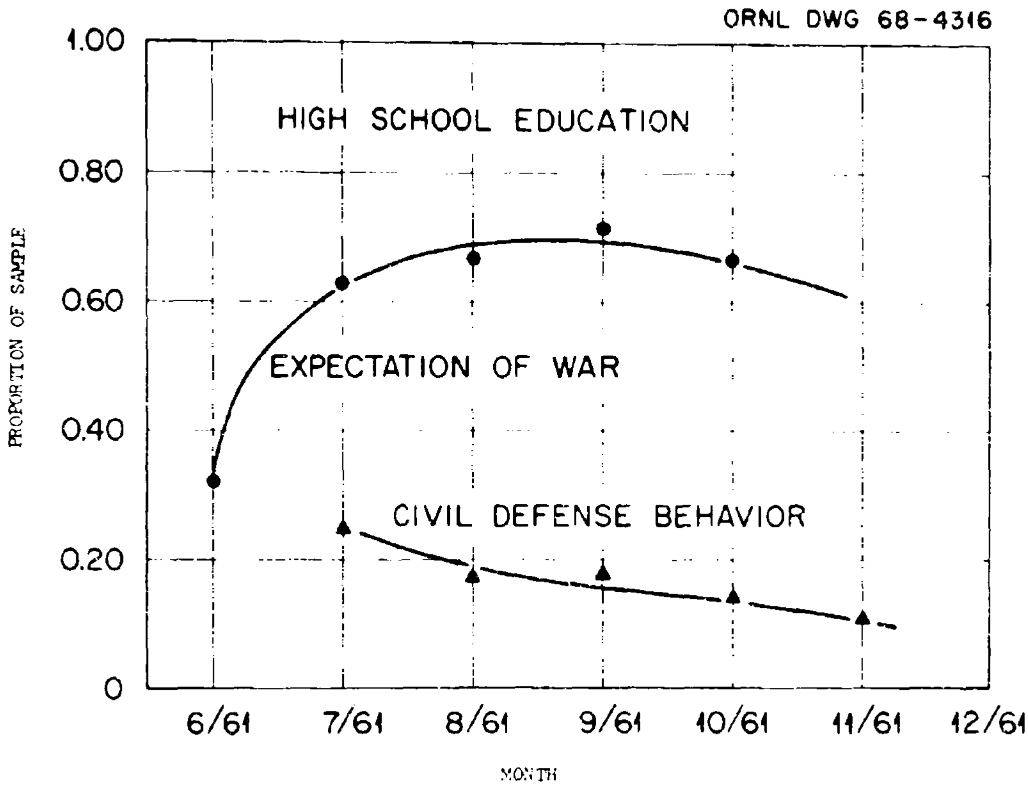



Fig. 15.3. Proportion of Moderate Education Respondents Expecting War and Engaging in Civil Defense Behavior During 1961 Berlin Crisis.

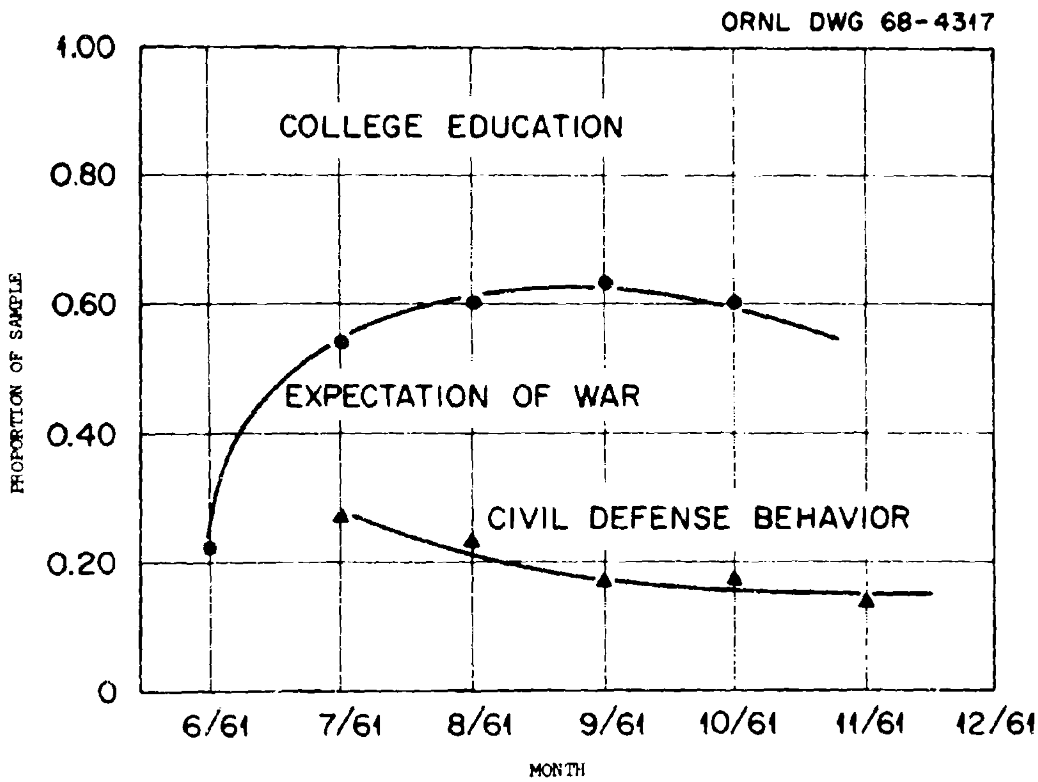



Fig. 15.4. Proportion of High Education Respondents Expecting War and Engaging in Civil Defense Behavior During 1961 Berlin Crisis.

Figure 5 represents the scores of all three education groups on the expectation of war variable.

Figure 6 represents the scores of all three education groups on the civil defense variable.

Before discussing the implications of these figures, a clarification of Figure 6 is in order. The solid lines in that graph represent the trend line for the actual data, the dashed lines represent projections backward in time which will be discussed in full later.

Rather than considering the hypotheses in order, we will consider the figures in order of presentation:

(1) Figure 1 indicates that there is little if any correspondence between expectation of war and civil defense behavior. The civil defense curve shows a steady decline even while the expectation of war curve continues to rise. This is contrary to Hypothesis 2a which suggested a positive correlation between the two variables. A conclusion cannot be reached, however, because of the lack of data on the civil defense variable for the sixth month of 1961. As shall be seen, the projection of that data point will have a profound effect on several of our conclusions, this one included.

(2) Figures 2, 3, and 4 show that the correspondence between the trend lines for expectation of war and civil defense behavior increases as education decreases. Again, this is contrary to Hypothesis 2d which states a positive not negative relationship. This conclusion is tenative because of the missing data point.

(3) Figure 5 indicates that the higher the education level of the group, the lower their expectation of war regardless of crisis level. There is some indication that the difference may be minimal during periods of crisis deescalation such as the latter stages of the Berlin Crisis because of less rapid declines in the expectations of the high education group. Nevertheless, the differences are consistant and in the direction predicted in Hypothesis 2b.

(4) Figure 6 indicates that the higher the educational level of the group, the greater the tendency to engage in civil defense oriented behavior regardless of crisis level. The sole exception was during the

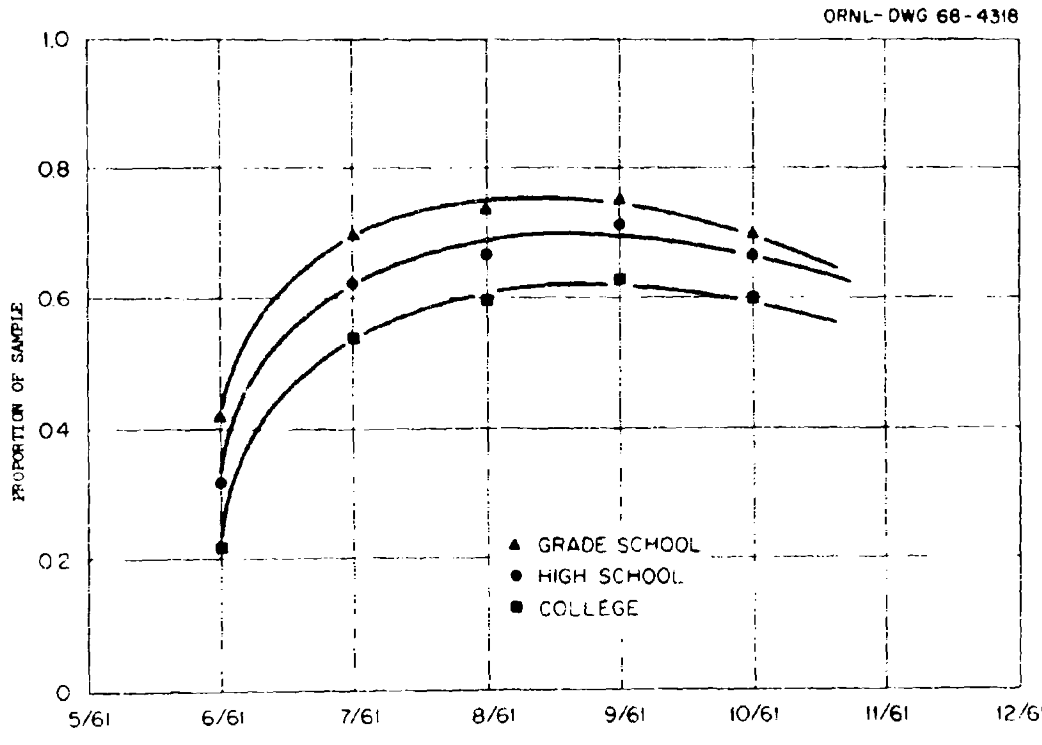



Fig. 15.5. Proportion of Education Groups Expecting War During 1961 Berlin Crisis.

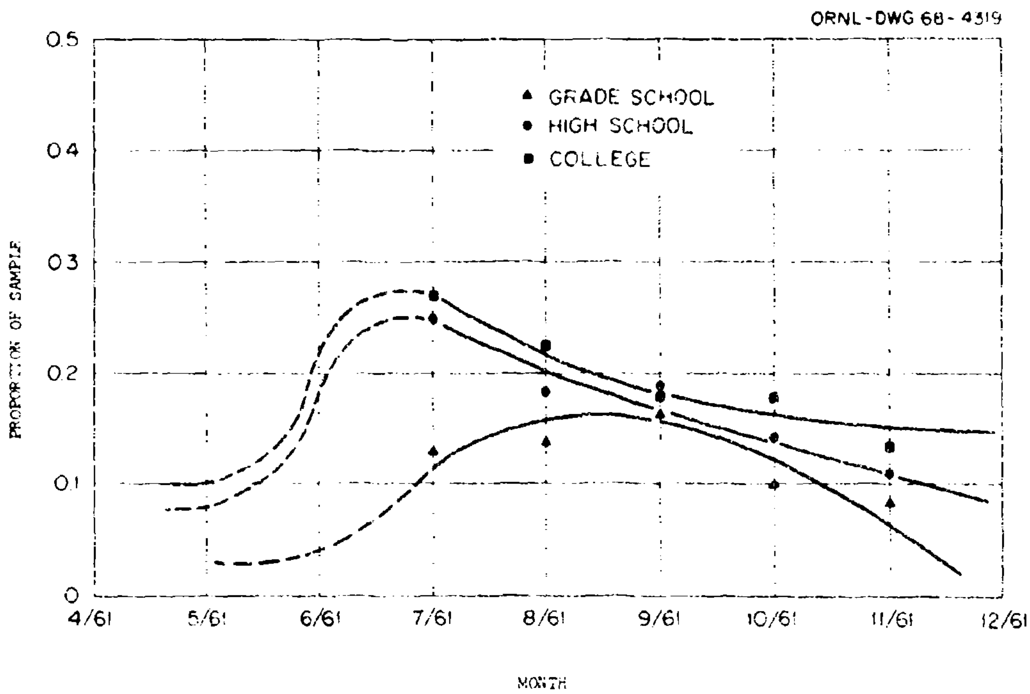



Fig. 15.[illegible]. Actual and Projected Proportion of Education Groups Engaging in Civil Defense Behavior During 1961 Berlin Crisis.

ninth month of 1961 when the high school education group was somewhat higher than the college group but other than that the differences are consistent and in the direction predicted in Hypothesis 2c.

As was mentioned earlier, the absence of data on the civil defense variable for the sixth month of 1961 greatly limits our ability to draw conclusions and in some cases may actually mislead the investigator and reader. The shape of the trend lines for that data which we do have in addition to some relevant data gathered before the crisis began allow the projection of the civil defense trend line into the early Berlin Crisis period. The data available indicates that in early 1961 the baseline response rates to questions about stored food were 10% for the college group, 7-8% for the high school group, and 3-4% for the grade school group. Using these as starting points, our curves can be projected as they have been in Figure 6 - the dashed lines representing the projection, the solid lines the actual data trend.

These projections force some modifications in the conclusions already tentatively drawn. Those conclusions dealing with the relationship between education and civil defense behavior or expectation or war remain the same and are extended. The conclusions concerning the relationship between expectation of war and civil defense must be changed. It now appears that for the total population, sharp increases in the expectation of war are paralleled by sharp increases in civil defense behavior but the correlation between the two then decreases because of the sharper decrease in civil defense behavior relative to expectations of war. The correlation between expectation of war and civil defense behavior is high during the early stages of a crisis for the college and high school education groups but not the grade school group. Conversely, the relationship is strong during the later crisis stages of the crisis period for the grade school group but not for the other two education groups.

(5) Figures 5 and 6 indicate that education level is related to speed or reaction to events only in the case of civil defense behavior. The response curves for the expectation of war are, for all practical purposes, parallel during the early stages of the crisis. The projected

civil defense responses indicate an early response by the college and high school groups and a much slower response by the grade school group. Thus, Hypothesis 1a is confirmed for the civil defense behavior variable but not for the expectation of war variable.

(6) Figures 5 and 6 show that the direction of the changes induced by the events is the same for all education groups for both expectation of war and civil defense behavior. The non-parallelness of the civil defense behavior curves is accounted for in terms of speed or reaction, the direction remains the same. Hypothesis 1b is confirmed for both variables.

(7) Figure 5 shows that the magnitude or extremity of the opinion changes of the educational groups did not differ from the expectation of war variable. Figure 6 indicates that although the high school and college groups evidence maximum change in civil defense behavior early in the crisis, the magnitude of the change is approximately the same for all three groups - 14% for the grade school group, 17% for the high school group, and 18% for the college group. Hypothesis 1c is not confirmed.

(8) Figures 5 and 6 show that the changes induced by the Berlin Crisis are longer lived the higher the education level. The differences between the high school and college groups are slight but both differ significantly from the grade school group. This conclusion is warranted for both expectation of war and civil defense behavior. Hypothesis 1d is confirmed.

## 15.5 DISCUSSION

The original set of hypotheses specified differential responsiveness to events as a function of education level. The finding indicate that such is the case for civil defense behavior but not for expectation of war. It is possible that the difference resulted from an artifact. The question about expectation of war resulting from the Berlin Crisis was asked of those who were aware of the Berlin Crisis while the civil defense question was asked of all respondents. It is possible that the difference between the college or high school group and the grade school group was based on differential awareness. This possibility can be

checked by comparing the civil defense behavior curves for the grade school group which was aware of the Berlin Crisis. Without reporting all the data, it is sufficient to say that the response curve for the aware portion of the group was essentially the same as the curve for the entire grade school education group.

Having eliminated this rival explanation, the implications of this finding are impressive. The lack of differential responsiveness of the education groups indicates one of two things. First, with major international events or major events in general, the "two-step flow of communication" is not operative because of the massive dissemination capabilities of television. This is probably true when the response to such information is emotional, i.e., involving the anxiety, grief, anger, rather than rational. The second possibility is that the two-step process still operates but with much greater speed than can be detected with a monthly measurement procedure. The speed could be accounted for by making the television commentator the first step or opinion leader. Since the commentator often follows a reporting of the news with an analysis and interpretation, the role of better educated and informed community member is bypassed and information is spread much more rapidly.

The civil defense behavior curves have three important implications:

(1) The time lag required for the low education group to adopt peak civil defense behavior levels indicates that even the simplest civil defense program such as stocking food must be regarded as a technological innovation which has to be disseminated to some parts of the population. This process of dissemination has been investigated with medical and agricultural innovations by Coleman, Katz, and Menzel (1957), Katz (1961), Rogers and Beal (1958), and Klapper (1961). To be effective, civil defense campaigns will probably have to be channelled through local "opinion leaders."

(2) Even during time of serious international crisis, the percentage of the population which will engage in any survival oriented behavior is quite small. In the case of stocking food, the maximum percentage for the total sample was 21%, for the high educational

group it was 27.5%. Thus the degree to which the public can be expected to protect itself in times of crisis is quite limited.

(3) Maximum protection in terms of civil defense behavior for a majority of the population (the high school and college education groups) is obtained immediately after a sharp rise in expectation of war. After that the tendency to adopt such measures begins to drop off even though estimates of the likelihood of war continue to increase. Those sections of the public appear to adapt rather quickly to the increased tension levels and the necessity of special protective measures seems to fade. It is probably that if a crisis lasts more than two or three months before escalating, the peak levels of what is already a minimal public effort will have passed.

## 15.6 REFERENCES


1. Berrien, F. K. "Shelter owners, dissonance, and the arms race," Social Problems, 1963, 11, 87-90.

2. Berrien, F. K., Schulman, C., and Amarel, M. "The fallout-shelter owners: A study of attitude formation," Public Opinion Quarterly, 1963, 27, 206-216.

3. Caspary, W. R. "United States public opinion during the onset of the Cold War: A study of public reactions to international events," Paper delivered at the Fifth North American Peace Research Conference, Peace Research Society (International), Cambridge, Massachusetts, 1967.

4. Coleman, A. "Fallout shelters: Some public views on their effectiveness," Department of Sociology, University of Pittsburgh, 1967.

5. Coleman, J. S., Katz, E., and Menzel, H. "The diffusion of an innovation among physicians," Sociometry, 1957, 20, 253-270.

6. Ekman, P., Cohen, L., Moos, R., Schlesinger, M., and Stone, G. "Divergent reactions to the threat of war," Science, 1963, 139, 88-93.

7. Farris, C. D. "Selected attitudes on foreign affairs as correlates of authoritarianism and political anomie," Journal of Politics, 1960, 22, 50-67.

8. Hero, A. O. Americans in World Affairs. Boston: World Peace Foundation; 1959.

9. Hero, A. O. "The American public and the U.N.," Journal of Conflict Resolution, 1966, 10, 436-475.

10. Katz, E. "The two-step flow of communication: An up-to-date report on an hypothesis," Public Opinion Quarterly, 1957, 21, 61-78.

11. Katz, E. "The social itinerary of technical change: Two studies on the diffusion of innovation," Human Organization, 1961, 20, 70-82.

12. Katz, E. and Lazarsfeld, P. F. Personal Influence: The Part Played by People in the Flow of Mass Communication. New York: Free Press, 1955.

13. Klapper, J. T. The Effects of Mass Media. New York: Free Press, 1961.

14. Lazarsfeld, P. F., Berelson, B. R., Gaudet, H. The People's Choice. New York: Columbia University Press, 1948.

15. Mast, R. H. "Impact of the Cuban missile crisis: Patterns of public response," Department of Sociology, University of Pittsburgh, 1966.

16. Nehnevajsa, J. "Americans' views on civil defense in the Cold War context: 1966," Department of Sociology, University of Pittsburgh, 1966.

17. Nehnevajsa, J. "Shelter assignment concept: A study in public acceptance," Department of Sociology, University of Pittsburgh, 1967.

18. Nehnevajsa, J., Brodie, D. V., Krochmal, D., Pomeroy, R. "Some public views on civil defense programs," Department of Sociology, University of Pittsburgh, 1964.

19. Pool, I., Abelson, R. P., and Popkin, S. Candidates, Issues and Strategies. Cambridge, Massachusetts, 1966.

20. Popkin, S. "Crisis level and civil defense attitudes," The Simulmatics Corporation, Cambridge, Massachusetts, 1966.

21. Rogers, E. C. and Beal, G. M. "The importance of personal influence in the adoption of technological change," Social Forces, 1958, 36, 329-335.

22. Rose, P. I. "The public and the threat of war," Social Problems, 1963, 11, 62-76.

23. Rosi, E. J. "Mass and attentive opinion on nuclear weapons tests and fallout: 1954-1963," Public Opinion Quarterly, 1965, 29, 280-297.

24. Scott, W. A. "Psychological and social correlates of international images," In H. C. Kelman (ed.), International Behavior: A Social-Psychological Analysis. New York: Holt, 1965.

25. Smith, P. A. "Opinions, publics, and world affairs in the United States," Western Political Quarterly, 1961, 14, 698-714.

26. Withey, S. B. "The U. S. and the U.S.S.R.: A report of the public's perspectives on U. S. - Russian relations in late 1961," Survey Research Center, University of Michigan, 1962.

## 15.7 Acknowledgements

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# 16. GENERATIONAL TRENDS IN AMERICAN PUBLIC ATTITUDES TOWARD NATIONAL SECURITY

Neal E. Cutler*

## 16.1 INTRODUCTION

A comprehensive search for reliable empirical indicators of public attitudes, beliefs and orientations concerning matters of public policy requires the analysis and interpretation of a relatively large file of public opinion data. To this end, a data bank containing over one hundred national sample public opinion surveys, spanning the years 1946-1966, has been established by the Civil Defense Research Project, Oak Ridge National Laboratory. The present report contains some initial analyses from the first longitudinal, multiple-survey research project emanating from the establishment of the survey data bank.[1]

### 16.1.1 Some Questions Which Can Be Answered By Survey Research

There is no doubt that one of the most significant problem areas of our times is the relationship between the nation and its external environment, namely, diplomatic and foreign policies, active and passive defense policies, and the mobilization of domestic resources to evaluate and support these policies. In the present report we shall refer to this complex of issues as national security policy. Any empirical investigation of national security policy must formulate a number of important questions. Among them should include the following.

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What are the manifest policy attitudes shared by members of the public? How does the public view specific national strategies in the area of diplomacy and foreign affairs; in the area of military and defense planning and programs? In addition to these kinds of manifest policy attitudes concerning matters of national security, the scientist must consider a number of background policy-relevant attitudes. How does the public view national security problems in terms of priorities relative to other kinds of problems? How does the public perceive threats from the external environment, both in terms of crisis events and in terms of other national actors?

When these initial descriptive questions are answered, a second set of questions must be raised; namely, what are the relationships between manifest policy attitudes and the perceptual, cognitive, and other basic attitudes and beliefs? For example, does the public tend to favor certain manifest defense policies only during times when threatening crises appear, or are such attitudes generally held over a long period of time. Does support for alternative national security policies come from identifiable subgroups within the public, subgroups which can be identified in terms of the policy-relevant background attitudes? Are there significant personal characteristics -- sociological, psychological, and political -- which share strong relationships with manifest policy attitudes.

A final set of questions raises the problem of contingency. Under what contingent conditions are we most likely to find (a) specified levels of national security attitudes, (b) identifiable patterns of policy-relevant background attitudes, and (c) particular sets of relationships between these two? The important point raised by the question of contingency, of course, is that of estimating the parameters of future public support for the various kinds of attitudes and attitude interrelationships described here. The planning of national security policy in the context of public support of such policy demands reliable empirical knowledge of the elements of stability in public attitudes, as well as knowledge of the predictability of variance in conditions of foreseeable contingencies.

Of course any one piece of research raises more questions than it answers. What we have attempted in the preceding paragraphs is an outline of some important questions which not only should be answered, but may well be answered by the program of survey research being conducted by members of the Civil Defense Research Project.

16.1.2 A Multi-faced Program of Survey Research

The search for empirical answers to the questions illustrated in the preceding section demands both a long-term research program and a multi-faceted research program. At least three separate approaches to the secondary analysis of existing survey research data can be described. Each of the following approaches has been or is being implemented by members of the Civil Defense Research Project.[2]

A. Multivariate Analysis: It is common knowledge that many words can stand for the same concept or idea. Similarly, many alternative public opinion items can identify or measure the same attitude. An important task in the attempt to locate reliable indicators of national security attitudes is the search for clusters or sets of items which all measure the same attitude, and then construct from the cluster a single scale or factor which efficiently represents the attitude. The work by Bobrow and Wilcox, reported in the last Civil Defense Research Project Annual Report exemplified this approach.[3]

B. Event Sensitivity Analysis: While the multivariate reduction of a cluster of attitudinal measures to a single, hopefully stable, factor is one way of representing attitudinal stability, a second approach attempts to determine the sensitivity of attitudes to international events and crises. It may be expected that certain kinds of national security attitudes are more sensitive to the nature of the external environment, i.e., are more sensitive to events, than other attitudes. Similarly, certain population groups within the public may be more attentive and sensitive to such events. The empirical discovery of these loci of attitudinal change demand a series of measurements, before, during, and after the international crisis. The research by

Atkinson, described in Chapter 15 of the present <u>Annual Report</u> embodies this approach in analyzing the sensitivity of national security attitudes to the events of the Berlin crisis of 1961.[4]

C. <u>Longitudinal Analysis</u>: A third approach to the study of the stability of national security attitudes is to observe the longitudinal trends in the attitudes over a fairly lengthy period of time. To what extent, it may be asked, are the "basic" attitudes which have been located by way of multivariate analysis and studies over short-term periods, held by a national population over a long time? Certain attitudes relevant to national security policy, of course, will change as the policies themselves change. Yet it is also possible to locate sets of attitudes which are stable and predictable beyond the time-span of particular policies, particular crises, particular presidential administrations, and particular political debates. The present research into generational trends in national security attitudes is an attempt to gauge the longitudinal pattern of several different attitudes over the years 1946-1966.[5]

### 16.1.3 Scope of the Present Report

One of the most interesting longitudinal social phenomena is the process of generational seccession. Here is a perpetual process which combines sociological and psychological as well as biological mechanisms into a single process. Unlike generations of butterflies, each of which dies off before the succeeding one arrives on the scene, human generations overlap, coexist, and communicate with one another. Herein lies the excitement of the generational analysis of human behavior, for within the structure of overlapping generations is contained the seeds of both socio-political continuity as well as socio-political change.

As will become apparent later in this report, there are a great number of different kinds of research directions which can be pursued in using that form of generation research we call cohort analysis. Not all questions relevant to an understanding of public attitudes toward matters of national security policy can be asked, let alone answered, in a single study. The purpose of the present section, therefore, is

to describe some of the research foci which we plan to investigate employing cohort analysis.

When it is said that a given aspect of human behavior correlates with the age of the actor, two interpretations may be given to the correlation. One states that age is a measure of the life-stage of the person, that is, that congeries of social experiences, obligations, and expectations that characterize a person who has lived for a particular amount of time. On the other hand, age also denotes a generational group to which the person belongs. Having been born into a particular generational group, which confronts history at a particular time, can also have an effect upon the attitudes, beliefs, and values which a person holds. Thus, the analysis of national security attitudes, in the context of the age variable, can be approached from both the generational and aging points of view.

We may also ask a set of questions pertaining to longitudinal patterns of attitudes for certain subgroups within the national population. For example, as measured over the period 1946-1966, do the trends in attitudes for men parallel those for women or are there identifiable and significant divergences? Similarly, there is evidence that individuals who possess different levels of formal education also possess different ways of structuring their beliefs.[6] A longitudinal analysis of national security attitudes may reveal significant differences in the belief structures of these various educational groups.[7] Finally, research focussing upon national samples at one point in time has revealed that significant differences in attitudes toward matters relative to national security are associated with personal and psychological characteristics.[8] It remains to be seen if the characteristics associated with national security attitudes at a single point in time produce stable relationships when analyzed longitudinally.

As a final step in locating the present report in the larger project of which it is a part, we should point out that what we mean by "national security attitudes" covers a variety of different attitudes. As pointed out in Section 10.1.1, we may investigate manifest attitudes toward various specific and general policies, as well as latent or

background attitudes which may generate support for alternative new policies. Similarly, we may investigate the interrelationships between manifest and latent attitudes and attempt to determine the contingencies under which the interrelationships hold. In the present report we shall present only a portion of the data which have already been analyzed, which in turn is but a small portion of the investigation now under way. More specifically, we will examine the attitudes of three separate generations to four national security policy preference attitudes; that is, attitudes which express a manifest preference for a particular kind of action in the realm of national security planning, as distinct from latent or background attitudes.[9]

## 16.2 THE RESEARCH PROBLEM STATED IN TERMS OF THE THEORY OF GENERATIONS

The basic research problem is to trace American attitudes toward national security over the period 1946-1966. The simplest approach to such a problem would be to merely plot the percentage of Americans who have given favorable or unfavorable responses to various policies or proposals over the years. This approach, however, would fail to provide two of the most important products of any scientific investigation of a problem: the understanding of the genesis of the trend lines, and a reliable basis for predicting future states from the trends. For these reasons, the research reported here has been designed in the context of the theory of generations.

To what extent, it is asked, are attitudes toward problems of national security related to the emergence of successive human generations? Do historical events and circumstances provide a background for the establishment of attitudes and beliefs which the individual holds even as he grows older and undergoes the various changes associated with the aging process? To what degree are beliefs concerning the use of war as an instrument of national policy, the extension of American military forces to other parts of the globe, the expenditure of national resources in the form of foreign aid -- to what degree can these kinds of beliefs be accounted for in terms of a theory of generations?

Generational succession is a basic law of social existence with which social scientists must contend.[10] Certainly each new generation develops in an environment shaped by prior generations, and is highly influenced by the constraints and beliefs handed down through the culture generally, and through parents specifically. Yet ea h generation is confronted by a unique configuration of historical and contemporary social, political, and international forces which can make that generation different from all previous ones. If the community of social scientists can establish the linkages between the processes of generational succession on the one hand, and the processes which shape patterns of social and political behavior on the other, then a mode of explanation and prediction will have been discovered which is most powerful.

When analyzing behavioral patterns which are to be related to a person's age, we must acknowledge an alternative model, one based upon the aging rocess of man. There are, according to the alternative, characteristic behavior patterns of youth and characteristic behavior patterns of elder persons. In the political realm, for example, youth is seen as radical while the elderly are seen as inherently conservative. This alternative may be called a "life-cycle" model of human behavior, since every individual in fact travels through such a cycle, the linkage between behavioral and biological proce es can become a significant explanatory tool for st dents of huma behavior.[11]

It is important to both theoretically and empirically distinguish the life-cycle and generational explanations of human behavior since each implies a severely different model of political change. If one is interested in the forces which promote or hinder changes in a political system, then certainly the profile of behavior patterns possessed by new groups of system members is a most important element for study. The life-cycle interpretation of the age variable implies a static model of political system change. For example, if individuals change in a "characteristic" fashion from youthful radicalism to elderly conservatism, then one would expect this same pattern to iterate with each successive generation. While the life-cycle interpretation of

age-correlated behavior results in a cyclical pattern over time, it nonetheless implies a relatively static picture of the political system in that each iteration of the cycle develops in the same way as previous iterations.

The generational interpretation of observed age difference in behavior provides a more dynamic model of political change. This generational model implies that the unique complex of historical circumstances under which a generational group is born and is socialized will influence the political values and beliefs it holds to be important. More importantly, the generational model implies that those political postures which the generational group formulates early in its own life history will be carried forward into time as that generational group ages. Thus, as each generational group ages into that life-stage from which leaders are selected, it brings to leadership a set of political orientations which may be different from those of previous generations of leaders.[12]

## 16.3 COHORT ANALYSIS: A METHODOLOGY FOR STUDYING GENERATIONAL TRENDS

The concept of the age cohort, most thoroughly developed by students of demography, is defined as a group of persons who share some important life-cycle event, usually the year of birth, although the event could also be the year of entering military service, the year of first vote, etc. Evan, in "Cohort Analysis of Survey Data: A Procedure for Studying Long-Term Opinion Change," describes a procedure whereby the demographer's conception of cohort analysis can be adapted for use with a large number of attitude surveys.[13] If one wanted to study the attitudes of a particular cohort in five year intervals over the period 1945 to 1965, for example, one could look at the twenty-five year-olds in a 1945 survey, the thirty year-olds in 1950, the thirty-five year-olds in 1955, the forth year-olds in 1960, and the forty-five year-olds in 1965. Although the analyst does not have measures on the very same individuals from year to year, as the demographers have in the form of census records, he can assemble comparable samples of the same cohort as that particular cohort ages over time.

The secondary analysis of survey data by this cohort approach allows the researcher to observe a single generational group in a longitudinal perspective using a series of cross-sectional data. Cohort analysis allows for the statement of inferences which are not possible in the use of single cross-sectional studies. Although collections of survey data have been in existence for a number of years, there has been little work aimed at using these archives in the location of longitudinal inferences. As Lipset has commented, "Unfortunately there has been no attempt to study systematically the effect of generation experience with modern survey research techniques."[14] In a more recent synthesis of social research focussing upon the various factors and agencies which affect the development of social and political attitudes, Dennis says of the generational model that "this is one of the areas of political socialization research where least is known."[15]

The age variable, of course, has been used in a great many studies of political attitudes, where the researcher "controls" for age; that is, he can identify differences at a single point in time between twenty year-olds and seventy year-olds. The inference is often drawn to the effect that the process of aging accounts for the age differences. Yet it is important to recognize that these two age groups are members of different cohorts, age groups which have been influenced by, perhaps, radically different socialization experiences in their youth and early adulthood. For example, a cohort analysis could reveal that present-day conservative seventy year-olds were just as conservative as when they were twenty years old. This socialization-oriented inference is quite different from the life-cycle or aging-oriented inference. Yet the error is quite easily made when the study is based upon a single cross-sectional sample. One of the primary contributions of the ongoing research project described in this report, therefore, is the formulation of a set of procedures wherein the errors of inference inherent in cross-sectional analyses may be reduced.

Since the theoretical orientation of this research is <u>generational</u>

and the analytic model is that of cohort analysis, the relationship between "cohort" and "generation" should be made clear. As stated above, a cohort may be arbitrarily designated by a researcher in terms of (a) the number of years which constitute a cohort interval, and (b) the event which defines a cohort, e.g., birth, entrance into military service, etc. A generation, on the other hand, has usually been defined solely in terms of birth, and usually encompassing a period of twenty-or-so years. In historical discourse, for example, a generation has been usually defined as "the average period from a male's birth until the birth of his first male child. Nowadays a generation so defined is much closer to twenty years in duration."[16] In his essay titled "How Long is a Generation?" Berger observed that in recent history the time periods which in fact define separable generational groups have been shrinking.[17] The increased pace of technological change suggests that researchers should look for qualitative generational differences at intervals which are smaller than the traditional twenty year period.

By employing the concept of cohort, the researcher is in the position to determine if in fact a generation-defining event has occurred which substantially differentiates the behavior of those born and socialized immediately following the event. In the present research, for example, the events of World War I, the Depression, and the coming of the Nuclear Era, although less than twenty years apart, may in fact define distinct generational groups. Addressing himself to the advantage of employing the cohort concept in the analysis of social change, the demographer Norman Ryder has stated that "the proposed orientation to temporal differentiation of cohorts emphasizes the context prevailing at the time members of the cohort experience critical transitions."[18] To the extent that such critical transitions coincide with major historical watersheds which occur more frequently than every twenty years, then cohort analysis will reveal differential patterns of human behavior at intervals less than that defined by the traditional concept of "generation."

Table I may be called a "cohort analysis matrix" and represents the generic form in which a series of national sample surveys must be cast in order to construct cohort comparisons.[19] Each column in the

Table I: Cohort Analysis Matrix: Five-Year Intervals

| | 1946[a] | 1951 | 1956 | 1961 | 1966 |
|---|---|---|---|---|---|
| Nuclear Era | 21-25[b] | 21-25 | 21-25 | 21-25 | 21-25 |
| | 26-30 | 26-30 | 26-30 | 26-30 | 26-30 |
| | 31-35 | 31-35 | 31-35 | 31-35 | 31-35 |
| Great Depression | 36-40 | 36-40 | 36-40 | 36-40 | 36-40 |
| | 41-45 | 41-45 | 41-45 | 41-45 | 41-45 |
| | 46-50 | 46-50 | 46-50 | 46-50 | 46-50 |
| World War I | 51-55 | 51-55 | 51-55 | 51-55 | 51-55 |
| | 56-60 | 56-60 | 56-60 | 56-60 | 56-60 |
| | 61-65 | 61-65 | 61-65 | 61-65 | 61-65 |
| | 66-70 | 66-70 | 66-70 | 66-70 | 66-70 |
| | 71-75 | 71-75 | 71-75 | 71-75 | 71-75 |

[a]Each column is represented by a sample survey taken in the given year.

[b]The cohort represented by the uppermost pair of diagonal lines was born in 1921-25. Thus the entries in this diagonal "row" may be read as follows: "The cohort born in 1921-25 was 21-25 years old in 1946; it was 26-30 years old in 1951, 31-35 years old in 1956, etc."

table represents a national sample survey; five such surveys have been chosen at five year intervals representing a twenty year period. The respondents in each of these surveys have thus been sorted into five-year age groups. Using this format, the development of any given generational cohort can be traced by observing successive samples of the cohort across the five sampling points. For example, observe that cohort born in the 1921-1925 interval: This cohort occupies the 21-25 age-group cell in a 1946 sample; in 1951 all members of this cohort have aged five years, and thus the cohort would now occupy the 26-30 age-group cell in a 1951 sample. One can similarly "age" the cohort another five years by looking at the 31-35 age-group cell in a 1956 sample, and continue the operation for as many sample-survey points for which data are available.

In the actual cohort analysis of any specified aspect of political behavior, the cells in this cohort analysis matrix would be occupied by measurements on that behavioral variable. In other words, a cross-tabulation of age-by-variable is obtained for each of the sampling points, and the resultant frequencies, precentages, or scores are entered into the matrix. By scanning the matrix diagonally, the pattern of these scores for a given cohort can be traced across time. Assuming that the samples are in fact representative of generational cohorts, several kinds of comparisons can then be constructed. One may merely want to observe the pattern of attitudes of one particular cohort, looking at several different attitudes. The researcher may want to focus upon a single attitude, and compare one generational cohort with another.

Although the analytic technique described in this report is called <u>cohort</u> analysis, information about the generational cohort is only one aspect of the information which can be obtained. Cohort analysis can also provide information about the effects of the aging process. Referring again to Table I, each row represents a particular stage in the life-cycle. The top row, for example, represents the 21-25 year life-stage in each of the sampling points. The individuals represented in the cells of the rows are not samples of the same

individuals. Rather, each row represents a series of samples of individuals who occupy the same stage in the life-cycle. One may hypothesize, for example, that there is something inherent in youth which leads to liberal political beliefs. If the cells of the cohort matrix represent scores on a liberalism scale, then this hypothesis would predict that the row representing "youth" would be more liberal than rows representing older life-stages.

The technique of cohort analysis, therefore, can be applied to survey data. As long as the attitudinal information for each individual is accompanied by his age, the individuals represented in each sample can be sorted into age groups. By doing this to a succession of samples, the analyst can trace attitudinal patterns across both generational and aging process dimensions. Since cohort analysis in fact facilitates the observation of both these effects of the age variable, a long-term research project is in a position to investigate the relative impact of each effect upon a given data set. The present report will focus solely on indicators of the generational impact upon defense policy attitudes.

### IC.- A COHORT ANALYSIS OF NATIONAL SECURITY ATTITUDES

This section will present the data representing defense policy attitudes of three distinct generational cohorts, as these attitudes have been recorded by a succession of national sample surveys covering the years 1946-1966. The three cohorts have been labelled as follows: "World War I" cohort, "Depression" cohort, and "Nuclear Era" cohort. In each case the label represents that group of persons which was approximately twenty years old at the beginning of the event included in the label. It should be remembered, however, that the labels are only shorthand ways of referring to these three cohorts. Although they could have just as easily been referred to as A, B, and C, the labels chosen here do convey something of the generational influences which are being investigated. Since the cohort analysis of a multiple-survey data collection requires a somewhat different set of

operational procedures than usually employed in single-sample studies, this section will begin with a brief outline of the methodological and statistical procedures employed.

16.4.1 The Standardization of Response Distributions Across Time

From the public opinion files of the Civil Defense Research Project, four general categories of attitudes relating to national security were established: (1) "Maintain/Increase American Military Capability" -- questions giving the respondent a situation in which he would favor or oppose such aspects of military capability as nuclear weapons testing, the draft, and missile systems. (2) "Non-Military Extensions" -- questions which asked the respondent if he favored the extension of American resources to other parts of the world as a way of maintaining American national security; literally, these questions refer to various forms of foreign aid. (3) "Military Extension" -- questions which asked the respondent for his attitudes concerning the deployment of American troops and other strategic resources to other parts of the world. (4) "Advocacy of War" -- questions in which the respondent was asked if the United States should declare war on its enemies.[20]

In analyzing attitudes in each of the above sets, we cross-tabulated the answers to each question with the age of the respondent. For any given question-set, however, some variance may be introduced merely by the fact that the 1946 question was worded differently than the 1951 question. In order to eliminate this spurious source of variation we performed a z-score transformation on the percentage data.[21] Table II demonstrates how we applied the z-score formula to out national security attitude data. Note that each of the "yes" percentages corresponds to an $x_i$. Thus, the $z_i$ for each age group represents the percentage, as corrected for (a) its deviation from the mean percentage and (b) the standard deviation of the vector of percentages.

TABLE II: EXAMPLES OF Z-SCORE DERIVATION:
"DO YOU EXPECT WAR IN 25 YEARS?"[a]

| Age Group | N | No | Yes | Z-Score ("Yes") |
|---|---|---|---|---|
| 1. 21-25 | [illegible] | 23.6% | 76.4% | 1.47 |
| 2. 26-30 | 317 | 24.3 | 75.7 | 1.2[illegible] |
| 3. 31-35 | 299 | 28.1 | 71.9 | 0.08 |
| 4. 36-40 | 331 | 25.7 | 74.3 | 0.93 |
| 5. 41-45 | 259 | 29.3 | 70.7 | -0.30 |
| 6. 46-50 | 26[illegible] | [illegible] | [illegible] | -0.7[illegible] |
| 7. 51-55 | 22[illegible] | [illegible] | 69.6 | -0.62 |
| 8. 56-60 | 1[illegible] | [illegible] | [illegible] | 1.31 |
| 9. 61-65 | 179 | [illegible] | 69.6 | -0.58 |
| 10. 66-70 | 10[illegible] | 31.[illegible] | 68.6 | -0.93 |
| 11. 71-75 | 6[illegible] | 33.9 | 66.1 | -1.71 |

Mean = 71.04[illegible]

Standard Deviation = 3.[illegible]

[a]Source: AIPO 379 (194[illegible])

16.4.2 Results

For purposes of analysis, the average z-score for each generational cohort was computed for each of the attitude question-sets. By comparing these mean z-scores, the reader is able to determine answers to a number of interesting questions. For example, within a generational cohort, which kind of national security attitude has the greatest endorsement (i.e., which has the highest mean z-score)? How does the internal structure of attitudes compare from cohort to cohort? What kinds of longitudinal interrelationships exist among the various attitudes (e.g., is a high level of support for foreign aid programs associated with a high level of support for sending American troops to other parts of the world)? In the analysis which follows, therefore, the data which are presented represent the mean z-scores given by each of the three generational cohorts, for each of the attitude question-sets.

Two modes of analysis for these data will be suggested here. First, the preferential structuring of defense policy choices of each cohort can be ascertained by observing the rank-order of scores within each column. Second, by scanning the rows, the reader can see the longitudinal trends in each of the defense policy question-sets.

Initial inspection of Table III reveals that there are in fact generational differences in attitudes toward the four national security question-sets.[22] The most preferred policy of the cohort which was approximately twenty years old at the time of World War I is to maintain or increase American military capability, while the least preferred policy is the extension of such military capability to other parts of the world. For the Depression cohort, however, the most preferred defense policy appears to be that of non-military extension. The question-set here described as "non-military extension" contains items pertaining to support for American foreign aid programs. At the same time, the policy least preferred by this cohort is the advocacy of war. That cohort which entered the political system (approximately age twenty) at the beginning of the nuclear era gives its greatest support

TABLE III: COHORT MEAN Z-SCORES FOR NATIONAL SECURITY POLICY-PREFERENCE ATTITUDES[a]

| Question-set | A World War I Cohort | B Depression Cohort | C Nuclear Era Cohort |
|---|---|---|---|
| 1. Maintain/Increase Military Capability | [illegible] | -.0[illegible] | .67 * |
| 2. Non-military Extension | -.[illegible] | .17 | .41 |
| 3. Military Extension | -.[illegible]3 | -.2[illegible] | 1.[illegible]0 ** |
| 4. Advocacy of War | -.0[illegible] | -.4[illegible] | .7[illegible] ** |

[a]In this table a measurement was taken on each attitude question-set at each of the five sampling points -- 19[illegible], 1951, 1956, 1961, and 19[illegible] (see Table I) -- where possible. As indicated in the text, it was sometimes the case that a particular question-set was not represented by a questionnaire item in one or two of these sampling points: those question-sets with one such observation missing are indicated above by a single asterisk; two asterisks indicate two missing data points. The complete text of all questions, as well as placement of missing data points, is given in Appendix I.

to a policy of military extension, and gives least support to the non-military extension or foreign aid policy. It will also be observed that all of the mean z-scores for this cohort are positive, as compared to the earlier cohorts whose scores are mostly negative. This indicates that the Nuclear Era cohort is, in historical perspective, more supportive of these general policies, regardless of their specific nature, than are earlier cohorts.

While observing the structure of the cohort columns indicates that there are observable generational differences in attitudes toward national security, the rows of Table III give a more general picture of the longitudinal trends for each of the four question-sets. It will be noticed that the total picture presented by these data is one of increased support for all four of the attitudes. For two of the question-sets, non-military extension and military extension, there are in fact monotonic increases in the levels of policy endorsement by each successive generational cohort. For the remaining two policy positions, attitudinal support increases as one compares the World War I cohort with the Nuclear Era cohort although the Depression cohort gives lower levels of support. One possible explanation for these latter patterns of policy endorsement may be made in terms of learning theory.[23] The higher levels of support given to question-sets one and four by the World War I and Nuclear Era cohorts may be a function of the fact that the significant generation-defining event in each of these cases was a "successful" military encounter. The two events may have served as positive reinforcement of the military policies embodied by the question-sets; hence in each case there is evidence of a positive societal-level learning experience.

Although a number of interesting findings can be isolated from the generational trends described by Table III, two in particular deserve further comment. A predominant generational trend is found in the military extension question-set. These items refer to the extension of American military commitments to other parts of the world in the form of sending troops to these other areas. The longitudinal trend

of increased endorsement of this policy appears to mirror the development of American defense and foreign policy during the period covered by these data, 1946-1966. The historically oldest cohort, socialized in the years before the emergence of the United States as a major world power, is least supportive of the collective security and containment policies implied by question-set three. The Depression cohort, while not strongly endorsing these policies, is less opposed to them than the World War I cohort. The Nuclear Era cohort, that group socialized at the beginning of the era in which the policies of military extension were stimulated and formulated, gives the highest level of policy support to question-set three; in fact, this level is the highest to be found in all of Table III.

The final trend to be commented upon here concerns attitudes toward the advocacy of war. It will be noted that of the three generational cohorts included in our analysis, the Nuclear Era cohort is most supportive of this particular approach to national security. This may seem somewhat paradoxical since some commentators have argued that the youngest generation, socialized as it was in the years which saw the first use of nuclear weapons, is most antagonistic to the use of such weaponry. We include comment on this aspect of our data to point out the need for further longitudinal research into the complex of belief systems which characterizes national security attitudes. Other kinds of attitudes which provide the cognitive background to more policy-oriented attitudes may provide keys to the interpretation of such findings as the one pointed out here. For example, if it was discovered that this most recent cohort expressed the belief that nuclear weapons would never be used in a war, then advocacy of war takes on a different meaning. Similarly, if the belief is held that despite a nuclear war, one's personal safety would not be threatened, then again, the policy which advocates war has a somewhat different meaning.

## 16.5 SUMMARY AND CONCLUSION

On the basis of these data illustrating the generational analysis of public attitudes toward problems and issues of national security, a number of comments should be made and inferences drawn. Foremost among these, of course, is to reiterate that the present analysis of the attitudes of three generational cohorts toward four sets of attitudes is but a small portion of the work which can be and is being planned and carried out. A greater number of cohorts will be included in future research, as will be a greater number of attitude sets relevant to national security. Yet even the data presented here portray some significant findings.

A first general implication of this research is of concern to both policy-makers and social scientists alike. The establishment of a large-scale data bank, containing public opinion surveys from previous years, when exploited with innovative methodologies and expansive research designs can provide reliable knowledge and insight concerning long-term trends in human behavior, knowledge which would not otherwise become available.

Substantively, our data provide tentative evidence that the historical circumstances surrounding the socialization of successive generational cohorts do affect, in differential patterns, the attitudes held by members of the cohorts; that is, the cohort analysis of national security attitudes reveals interpretable longitudinal trends. Perhaps these trends can be more clearly seen from our summary of the data appearing in Table III in graphic form. We have plotted each of the four question-sets in succession, each plot containing the measurements for each of three cohorts (World War I, Depression, and Nuclear Era, respectively). (see Figure 1)

One implication of these data is that there is, in general, an increasing longitudinal acceptance of various forms of national security policies by the members of successive generational groups. For each of the four question-sets, the most recent cohort gives greater attitudinal

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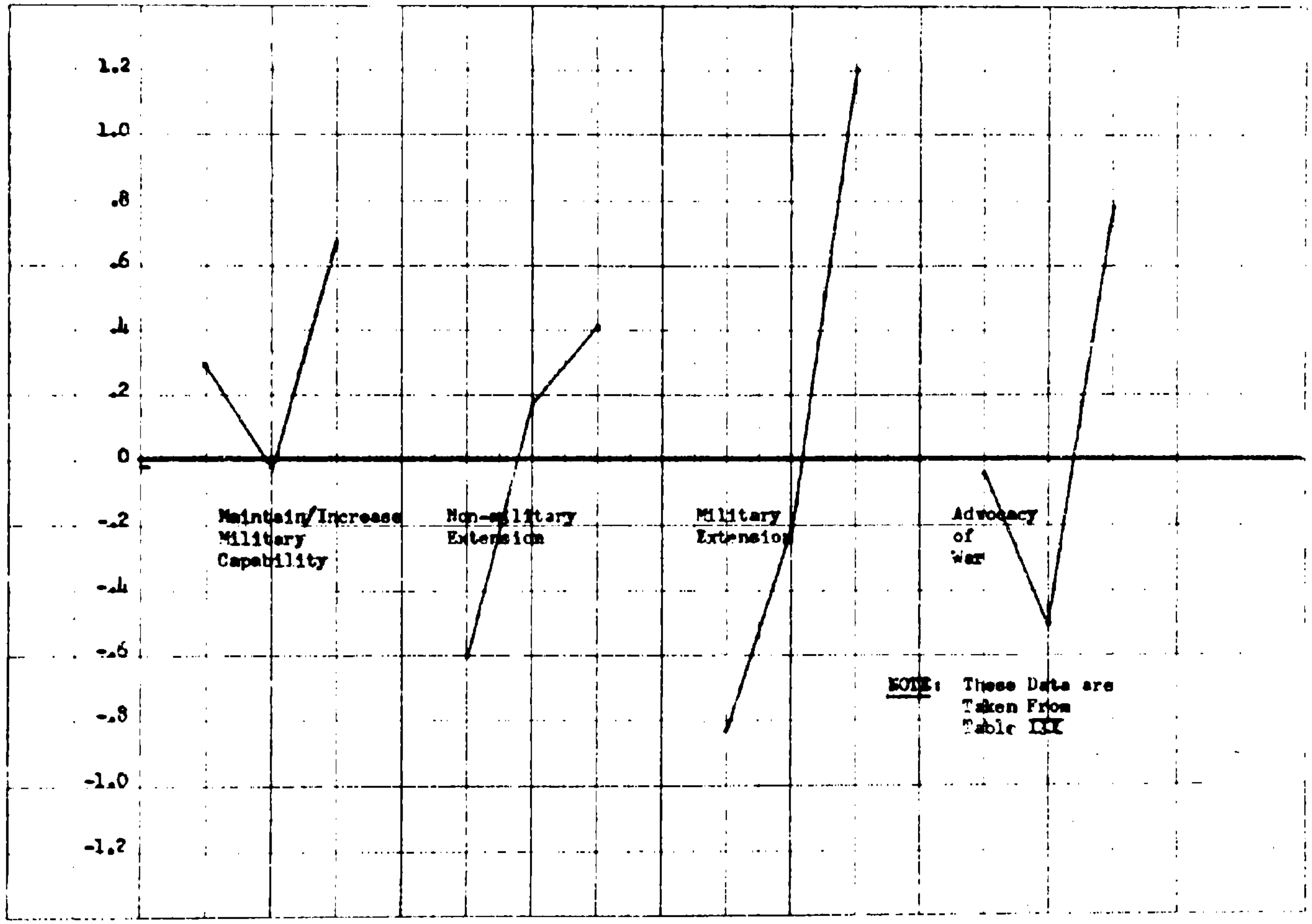


Fig. 16.1 Cohort Trends in National Security Attitudes.

endorsement of the policy than is given by the earliest cohort. Thus while in 1950 Almond argued that the public reacts to matters of foreign and defense policy solely in terms of "moods," our data indicate that there has been a fairly stable increase in public consideration of such policy matters.[24] The fact that this public support generally exists indicates that future planning in the area of national security must be made in this context of relative support and concern.[25]

Although public support has in general been increasing, policy-makers should remain attentive to the differences in levels of support for the alternatives illustrated by our four question-sets. Thus, while support for foreign aid programs is characterized by the general trend, support for American military extension has increased much more. The significance of this general longitudinal trend is increased as we observe that for the most recent cohort, military extension is given the largest amount of support.

Finally, it should be noted that those two question-sets which have been characterized by monotonic generational increases are both "extension" attitudes. The trends in public perceptions and endorsement of national security policies, in other words, are in the direction of increased extension of American resources -- both military and economic -- to other parts of the world. In terms of the classic isolationist-internationalist type of distinction, our data imply that the American public has become increasingly internationalist in orientation. Approaches to national security planning which desire to maintain public support should take these generational trends into account. Future research of this generational nature, however, will be able to locate more precisely those aspects of American involvement in the external environment which engender greater and lesser amounts of public support. To the degree that the kind of research which we have begun here is continued, decision-makers will be in a better position to accurately and reliably estimate the parameters of future levels of public support for alternative national security policies.

## 10.0 REFERENCES


1. The writer wishes to thank Davis B. Bobrow, Thomas H. Atkinson, and Eila S. Cutler for their helpful comments and reading of earlier versions of this report. Eila S. Cutler provided valuable assistance as manager of the Civil Defense Research Project's data bank.

   The data described here were originally presented in: Davis B. Bobrow and Neal E. Cutler, "Time-Oriented Explanations of National Security Beliefs: Cohort, Life-Stage and Situation," Peace Research Society (International) Papers, 8 (1968), in press.

2. For a comprehensive overview of this research program at its inception, including discussion of the following three phases, see: Davis B. Bobrow, "International Interactions, Surveys, and Computers," Presented at the Institute on Computers and the Policy-Making Community, Lawrence Radiation Laboratory, Livermore, California, April 4-15, 1966.

3. Davis B. Bobrow and Allen R. Wilcox, "Structure of American National Security Attitudes," Annual Progress Report, Civil Defense Research Project, March 1966-March, 1967, ORNL-4184, Part I, 1967.

4. See also: Thomas H. Atkinson, "International Crisis and Attitude Change: An Analysis of the Effects of International Events on Public Opinion," Doctoral Dissertation, Department of Psychology, University of Colorado, forthcoming, 1968.

5. For a fuller treatment of the methodological and analytic foci described in this report, see: Bobrow and Cutler, op. cit.

6. Philip E. Converse, "The Nature of Belief Systems in Mass Publics," in David Apter (ed.), Ideology and Discontent, New York: Free Press, 1964, pp. 206-261.

7. A conceptual discussion of the potential impact of educational differences upon attitudes relevant to national security issues is presented in: Neal E. Cutler, "The Alternative Effects of Generations and Aging Upon Political Behavior: A Cohort Analysis of American Attitudes Toward Foreign Policy, 1946-1966," Ph.D. Dissertation, Department of Political Science, Northwestern University, ORNL-4321, 1968, Chapter Five.

8. See, for example: Herbert McClosky, "Personality and Attitude Correlates of Foreign Policy Orientation," in James N. Rosenau (ed.), Domestic Sources of Foreign Policy. New York: Free Press, 1967, pp. 51-110.

9. The responses of these three cohorts to eight additional types of attitudes are presented in Bobrow and Cutler, op. cit. Samples of four additional generational cohorts will be analyzed in Cutler, op. cit.

10. The sociological significance of a theory of generations is attributed to Mannheim: Karl Mannheim, "The Problem of Generations," in Paul K. Kecshemeti (ed.), Essays on the Sociology of Knowledge by Karl Mannheim. London: Routledge and Kegan Paul, 1952, pp. 332-376.

11. An example of the life-cycle interpretation of political behavior is given in: John Crittenden, "Aging and Party Affiliation," Public Opinion Quarterly, 26 (1962), pp. 648-657. A reanalysis of Crittenden's data, however, indicates that in fact the generational influences upon party affiliation are stronger than the life-cycle influences. See: Neal E. Cutler, op. cit., Chapter Four.

12. For a theoretical exposition of the importance of the relationship of generational cohorts to social change, see: Norman B. Ryder, "The Cohort as a Concept in the Study of Social Change," American Sociological Review, 30 (1965), pp. 843-861.

13. William M. Evan, "Cohort Analysis of Survey Data: A Procedure for Studying Long-Term Opinion Change," Public Opinion Quarterly, 23 (1959), pp. 63-72.

14. Seymour Lipset, Political Man. New York: Anchor Books, 1960, p. 280.

15. Jack Dennis, A Survey and Bibliography of Contemporary Research on Political Learning and Socialization. Madison: University of Wisconsin Center for Cognitive Learning, 1967, p. 6.

16. Nelson Foote, "The Old Generation and the New," in Eli Ginzberg (ed.), The Nation's Children, Volume 3. New York: Columbia University Press, 1960, p. 6.

17. Bennett M. Berger, "How Long is a Generation?" British Journal of Sociology, 11 (1960), pp. 10-23.

18. Ryder, op. cit., p. 547.

19. Five-year intervals have been selected for this study due to the considerations of availability of data. That is, it was discovered that using five-year intervals maximized the number of defense policy indicators which could be subjected to analysis. Five-year intervals also allowed for the inclusion of the years 1946 and 1966, thus including the maximum number of years represented in the data bank. The logic and method of cohort analysis itself, however, does not impose any limitations on the size of the interval to be used. For another approach to the way in which cohort comparisons may be structured, see: Neal E. Cutler, "Agencies of Political Socialization: A Quasi Cohort Analysis," Unpublished Master's Thesis, Department of Political Science, Northwestern University, 1966.

20. A comprehensive discussion of the procedures employed in the selection of questionnaire items for analysis is presented in Cutler, "The Alternative Effects of Generations . . .," _op. cit._, Chapter Five. The complete text of all categories and items analyzed in the present report is given in Appendix I.

21. The formula for standardizing the percentages, i.e., creating z-scores, is as follows:

$$z_i = \frac{x_i - \bar{x}}{s}$$

where: $x_i$ is an element from a percentage vector, $\bar{x}$ is the mean of the vector, and s is the standard deviation of the vector.

An intermediate-level algebraic derivation of the z-score formula is given in William L. Hays, _Statistics for Psychologists_. New York, Holt, Rinehart, and Winston, 1963, p. 187.

22. The observation that a particular attitude varies over time in a way which is consistent with generational succession does not in itself "prove" that the factor of generational experience is the predominant cause of the pattern of variation. More extensive analysis of these same data, in fact, has demonstrated that other explanations may be more convincing. However, the fact that there are discoverable generational trends in these and similar attitudinal data is a significant datum which demands further exploitation. See: Bobrow and Cutler, _op. cit._, pp. 34-37.

23. The writer would like to express his thanks to Mr. Thomas H. Atkinson, Department of Psychology, University of Colorado, and ORNL Civil Defense Research Project, for pointing out this interpretive possibility.

24. Gabriel Almond, The American People and Foreign Policy, Second Edition. New York: Praeger, 1960 (originally published 1950).

25. Data presented elsewhere demonstrate an upward generational trend in the salience inputed to problems of national security and foreign policy by samples of the American public, a trend which parallels the data presented in the present report. See: Bobrow and Cutler, *op. cit.*, p. 26.

## 10.7 APPENDIX I

Text of survey questionnaire items included in each question-set

1. Maintain/Increase Military Capability

1946: The Selective Service draft law expires in May. Do you think Congress should or should not vote to continue the draft law for one year? (AIPO 397)

1951: If the Korean War is brought to an end soon, do you think the United States should continue our defense program as planned, or do you think the defense program should be reduced? (AIPO 477)

1956: *

1961: Since November, 1958, the U. S. and Russia have been trying to reach a permanent agreement on the control and inspection of nuclear bomb tests. During this period each country voluntarily agreed not to conduct any tests, but no permanent agreement has been reached. Do you think the United States should resume tests at this time, or not? (AIPO 652)

1966: What is the desirability of the United States' having anti-missile missiles so effective in shooting down enemy missiles that no enemy would think of attacking us? (NORC 876)

2. Advocacy of War

1946: Do you think the United States should declare war on Russia now? (AIPO 378)

1951: Do you think the United States should start an all-out war with Communist China, or not? (AIPO 471)

1956: *

1961: (If you have heard or read about the dispute between the Allies and Russia over Berlin . . . ) If Communist East Germany closes all roads to Berlin and does not permit planes to land in Berlin, do you think the United States and its allies should or should not try to fight their way into Berlin? (AIPO 650)

1966: *

3. Military Extension

1946: Churchill says that the U. S. and Great Brittain should make a permanent military alliance -- that is, agree to come to each other's defense immediately if the other is attacked? Do you approve or disapprove of this policy? (AIPO 367)

1951: Some people say that another world war is more likely to start is the United States sends additional soldiers to Europe. Other people say that our sending additional soldiers to Europe will more likely prevent another world war. With which group do you, yourself, agree? (AIPO 470)

1956: *

1961: (If you know of the Berlin dispute . . . ) Do you think we should keep American forces in Berlin -- along with British and French forces -- even at the risk of war? (AIPO 648)

1966: *

4. Non-Military Extension

1946: General Mark Clark believes that if we make a loan of 150 million dollars to Austria it may help to keep that country from coming under the control of Russia. Do you think we should make this loan to Austria? (AIPO 379)

1951: Do you think Congress should or should not vote about 8-1/2 billion dollars to European countries for military equipment and economic aid this coming year? (AIPO 477)

1956: During recent years, Congress has appropriated about 4 billion dollars each year for countries in other parts of the world to help prevent their going Communistic. Should Contress appropriate the same amount this year, or not? (AIPO 576)

1961: Do you think the interests of the United States have actually been helped by the U. S. Foreign Aid program during the last five years, or not? (AIPO 652)

1966: Various national programs frequently compete before Congress for financial support. I would like your opinion about the following programs, but please keep in mind that it is very unlikely that enough funds will be available for all of them: Aid to Developing Nations? (NORC 876)

*An asterisk indicates that no data are available for this sampling point, i.e., no question was asked in a national survey which would serve as an indicator of the particular question-set.

NOTE: AIPO = American Institute of Public Opinion (Gallup)

NORC = National Opinion Research Center

# 17. Emergency Preparedness in the Federal Executive Agencies

Claire Nader

## 17.1 INTRODUCTION

The focus of this work - discussed at some length in the Annual Progress Report of March 1966-67 - is the nonmilitary defense activities of the Federal executive agencies with special reference to a nuclear contingency. Its purpose is to examine the factors which shape and explain their preparedness efforts in this regard.

## 17.2 THE MEDICAL STOCKPILE PROGRAM

Analysis of the Federal civilian medical stockpile program[1] identifies (1) factors which shaped the practice and content of emergency preparedness in this area from 1951 to 1963, and (2) those which forced changes in the program. The work of the Task Force established in 1965 to evaluate the program and the consequent changes[2] resulted from a series of actions which were set in motion by the request in the fall of 1963, of the Assistant Director of the Bureau of the Budget (BOB), handling civil defense programs, for a review of the Public Health Service's emergency health program and for advice with reference to its 1965 budget.

It is noteworthy that in the two-year period from the time of the initial request the Public Health Service's Division of Health Mobilization did not complete the requested comprehensive review on which hinged the future of the program. To speed the process and to produce such an evaluation, an interagency task force was established. This move gave impetus to a thorough review and evaluation of the emergency medical stockpile program and a new program in 1966.

The events surrounding and affecting the emergency medical stockpile program from the fall of 1963 to 1966, give some idea of what

happened to move the program from routine administrative operations to a new and clearer political policy resolution and mandate. As a result of these, the issues were joined. In order to understand the kind of intervention which was required for substantive change to occur, something must be said about obstacles to change, that is, the conditions which created and then maintained the program's ineffective routine before and even after the transfer of stockpile responsibilities in 1960 from the Office of Civil and Defense Mobilization (OCDM) to the Department of Health Education and Welfare-Public Health Service (DHEW-PHS).

Several kinds of factors contributed to routine administrative behavior and operations from 1951 to 1963 and prevented the development of a continuously relevant program.

First, the program while in the Federal Civil Defense Administration (FCDA) from 1951 to 1960 suffered from organizational instability and discontinuity. During that time the Federal civil defense organization experienced several structural changes and even a breakup of its physical headquarters wherein from 1954 to 1957 the organization was located partly in Washington and partly in Battle Creek, Michigan. In this and in various other ways, FCDA lost whatever status it had in that hierarchy of organizations charged with defense policy and operations. Under such circumstances, the emergency medical stockpile program "got shuttled around," to use one official's description.

Second, the emergency health problem was conceived and developed not only in a limited organizational setting but also in a limited conceptual setting. The idea of emergency health was restricted to casualty care by the model on which the emergency medical care concept was patterned, the Mobile Army Services Hospital unit. The concept of continuing health was ignored in the organizational context of FCDA even though its importance was officially recognized in the early 1950's.[3] Moreover, since the problem of casualty care was seen against the background of the evacuation concept, strategic stockpiling of medical supplies and equipment became the accepted policy, persisting after

this concept was dropped. But strategic stockpiling was a limited policy even in the context of the evacuation concept because casualty reserves were not ready for emergency use.[4]

Third, organizational discontinuity and insecurity detracted from strong FCDA relations with its closest neighbors in the defense area, the Atomic Energy Commission (AEC) and the Department of Defense (DOD). An inadequatly funded independent agency, its organizational links with AEC and DOD, the agencies which possessed the knowledge basic to civil defense planning, were insufficient. FCDA experienced an isolation which damaged its ability to function as the public education branch of civil defense.[5] This isolation was reflected in inadequate communication, intensified by the distance of FCDA's main headquarters from the center of national defense decision-making.

A combination of factors contributed to inadequate communication and ultimately affected public education in civil defense planning and operations. Among these were:

(1) the slowness of declassifying information for public consumption, even though FCDA might have had immediate access to AEC-DOD classified information;[6]

(2) DOD and AEC uncertainty about the FCDA because of its public information function on civil defense matters;[7]

(3) lack of scientifically competent personnel in FCDA in contrast to the high level technical manpower in AEC and DOD;[8]

(4) insufficient interpretation of technical information from AEC-DOD so that FCDA could assimilate it and put it in useful form for public consumption;[9]

(5) contradicti .is between information contained in FCDA bulletins and statements made by FCDA officials.[10]

In the setting of a low status organization of little influence, the emergency medical stockpile program did not have much visibility. In fact, civil defense public relations programs did not allude to the hospital operation. Thus, no information about emergency hospitals got out in proper form to professional groups and to the communities.

Fourth, the program was plagued with inadequate staffing in terms

of numbers and qualified personnel. As early as 1954, the Surgeon General identified this problem.[11] As late as 1967, the shortage of medical personnel and the high demand for medical talent are still a problem. When it is available and allocated, emergency health tasks do not occupy a high place in the hierarchy of medical needs and demands.

Fifth, the program suffered from lack of leadership inside government and outside government. The liaison of the Federal civil defense organization with professional associations, advisory groups, and industry did not produce an effective program over time. At the Federal level of government, the organizational arrangements for emergency health, as least until 1966, did not reflect a division of labor appropriate to the task. Its placement in the Federal civil defense structure rather than in public health hindered an integrative system of support needed to sustain an emergency health program, although its transfer to PHS was not sufficient by itself. The program did not flourish in the highly valued setting of health operations and remained deficient under its auspices. The Division of Health Mobilization (DHM), which was established in response to the DHEW's emergency preparedness Executive Orders, did not appear to have much status in the departmental structure.[12] Until 1965, the DHEW leadership paid little attention to the medical stockpile program. For years the program was submerged by the inattention of top level leaders whose interest make a difference to a particular effort. Lacking in status and ineffective in conception and in operation, it was isolated from the dynamic setting in which policies and decisions are made.

Sixth, legal restraints continue to hinder efficient operating procedures. The Federal Property and Administrative Service Act of 1949 presently defines excess property as any property under the control of any Federal agency which is not required by its needs as determined by the agency's head. The problem is that an antibiotic is still needed in the medical stockpile program at the same time that it requires rotation because of its limited life. The Act does not allow for short-life items to be declared excess. Bills to amend it have been introduced in both houses of Congress (S. 1717 and H.R. 645), such amendments

permitting the redefinition of "excess property" to include short shelf-life items.[13] Legislation to this effect is expected in the current session of Congress.

A seventh factor obstructing change was the development of a set of operating norms over the years, which guided both those responsible for program coordination and efficient operations and those responsible for watching over the public funds allocated. This coalition resulted in the program's justification before Congress fundamentally as it was for thirteen years, with insignificant adjustments. As long as funds were appropriated, the situation was perpetuated. When the Bureau of the Budget withheld procurement funds and did not approve additional funds, the pretense was unmasked and something different had to happen. But it did not happen immediately, as already noted. Resistance to change was apparent and is not difficult to understand. For years habits, attitudes and associations had been developed which were associated with the then current program. Too ready an acceptance by the program's personnel of the Office of Science and Technology's (OST) negative evaluation — the review was made for the BOB — would have amounted to an acknowledgment of fundamental inadequacy on their parts. It was not easy for the responsible staff in the Office of Emergency Planning (OEP), and in PHS to admit readily to the BOB-OST criticisms. Even though the Bureau of the Budget could also be criticized for inadequate survillance of the public funds expended in this program, it had taken the initiative to correct the situation. At least the superiors of the budget examiner for civil defense were now insisting on accountability.

Eighth, this coalition of personnel from the BOB, PHS, and OEP contributed to a confusion of three critical functions which made change virtually impossible, namely, (a) watching over public funds, (b) operating the program, and (c) overall coordination of it. The state of disarray and ineffectiveness in which the program was found as a result of the numerous reviews it underwent from 1963 to the end of 1965 appears to support this observation. Essenti 'ly many of the same criticisms of the program could have been made almost a decade

earlier if the surveillance function of the Bureau of the Budget and the coordinating function of the Office of Emergency Planning and its predecessor had been operative. Instead, a high degree of coordination existed to sustain routine operations.

This coordination subverted the more positive effect that results from a separation of the watchdog, operating and coordination functions. It helps explain why a change in the program's organizational setting represented by the 1960 transfer from OCDM to PHS was not sufficient to have produced a complete evaluation at that time. The PHS inherited not only program responsibility but habits, attitudes and associations that had shaped it for a decade. Some of the same persons who had been involved in the program when it was in FCDA and OCDM were still involved in the PHS program and thus the same inadequacies persisted. Some of these individuals had been on loan from the PHS to FCDA and OCDM. The presence of a PHS officer on loan to OEP from 1961 to 1966 only served to mesh even further the coordinating and operating functions, thus strengthening the routine maintenance of the program's activities.

In summary, all of these factors together created substantial obstacles to change in the program. The old system of understandings had to be fundamentally disturbed for change to occur. Several agents of change provided such disturbance.

First, <u>the system of accountability was brought into play</u> when the Bureau of the Budget requested the Office of Science and Technology to review the program and advise on the 1965 budget for it. With this one action, the three functions - surveillance of public funds, operations, and overall program integration - were separated and the provocative process of checks and counterchecks reactivated. By its action the BOB in fact exercised its watchdog function. Necessarily then OEP and PHS-DHM's response had to be in terms of their official functions which the BOB action had made operative again. However, some time was required for the adaptation to be made from the routine administrative behavior which characterized the emergency medical stockpile program to the new conditions being set by this action.

The question which arises is what stimulated the interest of the

Bureau of the Budget after years of tolerating the emergency medical stockpile program at its unrealistic and unsafe level of performance standards. A key explanation concerns the Assistant Director of the BOB who sparked the Bureau's interest and who had the civil defense operation among his responsibilities. A personal preoccupation of his with long-range planning and an earlier involvement with civil defense matters served to lift the program out of its obscure setting into the limelight for careful scrutiny in the Executive Office of the President itself.

Second, change was facilitated by the entrance of the OST into the action arena. In effect, a new actor was introduced into the program's institutional setting with an acknowledged competent staff and with the full backing and prestige of the President's office. Its participation signalled to the responsible agencies that the criticism was to be taken seriously by, that top level leadership was clearly indicated. The lag in their response stemmed more from the program's long-time inertness than from a disregard for the source of simulation. Responsible officials needed to adopt new procedures to extricate themselves from a well-entrenched operating environment. Stress was a necessary but not a sufficient condition for change. Staff members still had to find for themselves a way of proceeding which would take them out of their routine. This was not easy after many years of established administrative practice.

A third agent of change was the Task Force which served a useful purpose in that it helped clarify functions. This in turn helped to clarify roles anew and allowed responsible persons to see a place for themselves in the new program environment being created by the Task Force of which they were working members. In effect, they were part of the process of setting the new conditions for the program's operation.

The opportunity to define the situation anew in the context of the Task Force where all relevant functions were represented helped release the frozen posture of officials responsible for the program. Objectives could be explored and reviewed from the different perspective of the members of the interagency committee before positions got

solidified and an emotional investment made in them. As one participant who welcomed this arrangement expressed the point, "They [the operating officials] can try some of their ideas on for size as they are developing them."

In sum, for routine administrative behavior to change and new directions to be mapped, new administrative procedures were necessary. The Task Force represented such a procedure. Its creation in August 1965, coincided with a stage in the adaptation process of officials to the changing situation. A readiness to change had had time to develop in the two year period from the fall of 1963 when the Bureau of the Budget had requested the program evaluation until August 1965. Many exchanges among the principals and the withholding of funds and approval of additional funds by BOB clearly pointed to the necessity for new departures in the program.

A fourth factor which stimulated change was the appointment of a new Surgeon General of the Public Health Service. Almost simultaneous with the establishment of the Task Force in August, the Surgeon General's appointment took effect in September 1965. At that time the deficiencies of the program were brought to his attention by a former respected associate. Upon his own review, the Surgeon General decided that the criticisms were justified and took steps to correct the situation. His clear orders to implement the Task Force's recommendations which came out in November 1965, and his filling the vacant office of the chief of the Division of Health Mobilization identified the leadership in PHS with favoring substantive changes which would put the program on a sound footing. The new chief of the DHM took over in the spring of 1966, to give operative meaning to the Task Force's recommendation, unencumbered by membership in the old program.

## 17.3 OTHER PROGRAMS

Improved Federal leadership is vital in programs whose operative effectiveness depends in great part on the voluntary cooperation of State and local officials and, in the medical stockpile case, on private

medical associations and operations.

Where the emergency preparedness operation is in the hands of a controlling group, performance standards are much easier to set and maintain. The leadership function is not diffused among so many actors. This is the case with planning and practice for the petroleum resource. Although the responsibility for this resource lies with the Department of Interior, the Federal government depends heavily on the organizational productive, and distributive efficiency of the petroleum industry in an emergency. A system of emergency responses has been developed by the industry in conjunction with the Federal government from World War II to the present. This has been exercised in peacetime especially by oil crises generated by political difficulties in the Middle East and stems understandably in part from the interest of the industry to maintain progress regarding the suitability of these responses under nuclear attack conditions.

The role of the Atomic Energy Commission in emergency preparedness presents yet another situation of centralized strength. Except for planning and operations for its own facilities, its involvement in nonmilitary preparations is in the main a responsibility for providing knowledge of nuclear weapons effects to the agencies with operating responsibilities. The AEC has a specific mandate for research and as a supplier of technical information. Over this activity it has complete authority and brings to bear its considerable power as the expert agency on atomic energy matters. In this sense, it is a "means" agency in search of problems. Civil defense is one such problem, linked as it is with AEC's legislative mandate to care for the public health and welfare. Aside from its own facilities, the Commission does not carry responsibility for implementing the findings of research.

Data on the Atomic Energy Commission's emergency preparedness efforts have been collected and are presently being analyzed for understanding the motivating factors for its nonmilitary activities.

## 17.4 REFERENCES


1. See Annual Progress Report, Civil Defense Research Project, March 1966-1967, pp. 125-34 for a discussion of the medical stockpile program and of the changes recommended by a special task force to strengthen it.

2. See U. S. House of Representatives Hearings on Independent Offices Appropriations for 1967 before a Subcommittee of the Committee on Appropriations on Emergency Health Activities of the Department of Health Education and Welfare. 89 Congress, Second Session, 1966. Part 1, pp. 1512-21, for the 1967 budget request and justification of the Division of Health Mobilization.

3. See the statement of Dr. Novin C. Kiefer, Director, Health Resources Division, Office of Civilian Mobilization National Security Resources Board in U. S. Congress, Civil Defense Against Atomic Attack. Hearing before the Joint Committee on Atomic Energy. 81st Congress, Second Session, 1950. Part 1, March 23, 1950, p. 19. Also Project East River, Civil Defense Health and Welfare, Part VIII (New York: Associated Universities, Inc., 1952), p.1.

4. See e.g., Report to the Congress of the United States of the U.S. Comptroller General, Weaknesses in Management of Vaccines Stored for the Civil Defense Medical Stockpile, July 1965, pp. 3-6.

5. The main purpose of the so-called Holifield hearing in 1956 was to examine the reasons for the ineffectiveness of the U.S. civil defense program and explore the desirability of establishing the Federal Civil Defense organization in the Department of Defense See U. S. House of Representatives. Civil Defense for National Survival, Hearings before a Subcommittee of the Committee on Government Operations (hereinafter Holifield Hearings). 84th Congress, Second Session, 1956, pp. 1-7.

6. Ibid., pp. 30, 913-14.

7. A former FCDA official who was closely concerned with its security matters gave as an example the AEC's initial reluctance to discuss publicly in sufficient detail to enable realistic planning the radiation exposure problem when the fallout threat became apparent. See ibid., pp. 64-65 for Commissioner Thomas Murray's criticism of public policies in this instance which stressed secrecy and Commissioner Willard Libby's reluctance to go so far. For further detail see U.S. Senate, Civil Defense Program, Hearings before Subcommittee on Civil Defense, Committee on Armed Services (hereinafter Kefauver Hearings). 84th Congress, First Session, 1955. Part 2 and Appendix, pp. [illegible].

8. Holifield Hearings, pp. [illegible].

9. Holifield Hearings, p. 40. Also Kefauver Hearings, p. 503.

10. Kefauver Hearings, p. 502.

11. See Medical Planning for Total War, issued by Division IV, of Medical Services Task Force, prepared for the Commission on Organization of the Executive Branch of the Government, December 1954. The report is reprinted in U. S. Senate, Hearings, Civil Defense Program, before the Subcommittee on Civil Defense of Committee on Armed services, 84th Congress, First Session, 1955. Part 2 and Appendix, p. 558.

12. Note that the chief position in DHM was vacant part of the time and, in effect, the program was without leadership in the critical period of transfer of responsibilities.

13. See Staff Memorandum No. 90-2-7, January 29, 1968, pp. 1-7, U.S. Senate, Government Operations Committee.

# VII. POSTATTACK RECOVERY

## 18. VULNERABILITY OF GRAIN STOCKS AND FOOD SUPPLY

A. F. Shinn

### 18.1 INTRODUCTION

Although mid-year carryover stocks of grains have generally trended downwards since the peak of 1961, the available crops in the field at mid-year 1967 taken together with the stocks constitute an apparently ample supply for emergency use. The mid-1967 national food supply is at least 1[illegible] months without counting the crops in the field. The geographic distribution of the stocks by states is grossly unequal, and shows only a few months' supply for some state populations whereas others have many years' supply on hand.

The National Advisory Commission on Food and Fiber has recommended both a program for adjusting carryover stocks of major farm commodities and a program to establish a national security or strategic reserve of farm commodities. A spate of Congressional bills have appeared in the wake of their recommendations. General comments are made on the bills as a whole.

The obviously unequal geographic distribution of food stocks underscores our dependence upon reliable transportation for their equitable distribution in a nuclear emergency. Inasmuch as the bulk of agricultural cargo is moved by motor truck, our dependence on adequate petroleum supplies is equally evident. The locations of the major distributional markets in large, probable-target cities suggest that alternative distributional patterns might well be delineated preattack for postattack use.

Previous presentations by members of this project have emphasized the vulnerability of our livestock to nuclear and biological attack. Recent overseas experiences with the viral foot-and-mouth disease of livestock has demonstrated the extreme difficulty of coping with it. Since lysine-fortified grain would make a good alternate source of protein,

it is suggested that lysine logically belongs in a strategic commodity reserve protram.

The role of the USDA Defense Boards is discussed with reference to a nuclear attack, and several recommendations for research in civil defense in agriculture are given.

## 18.2 THE NATIONAL FOOD SUPPLY

### Food Stocks as of July 1, 1967

The food stocks of major commodities are diagramed in Fig. 1 similarly to those in previous reports.[1,2] MARINE AND FRESHWATER FISH are relatively insignificant contributors to the supply, and the 0.13 days represents the catch for one month. FARM ANIMALS represent 105 days of food which calculation is based on the livestock inventory for January 1, 1967.[3] There are no statistics for mid-year livestock numbers, but this figure is likely to be a close approximation. STOCKS consist mostly of grains and the 405 days are 11% less than mid-year 1966 with a dramatic shift from 66% in private ownership in 1966 to 83% in 1967. The diagram includes the estimates of the FARM CROPS IN THE FIELD (GRAINS ONLY).[4] The composition of FARM ANIMALS, GRAIN STOCKS, and FARM CROPS is given in Table I, page 364.

The enormous amount of 1230 days, or 3.3 years, in FARM CROPS includes large amounts of food and feed grain which would normally be exported or fed to livestock. Not all of the grain supply is mature on July 1st, and even considerable harvesting of mature grains remains to be done. Results from the NRAC UNCLEX attack* show that there is a 50% probability (based on July 8th weather data) that approximately 60% and 78% of the cropland will be available for use in 10 days and 30 days, respectively.

*A 3600-megaton attack devised by the National Resource Analysis Center, OEP, and directed against a combination military-population-industrial target list.

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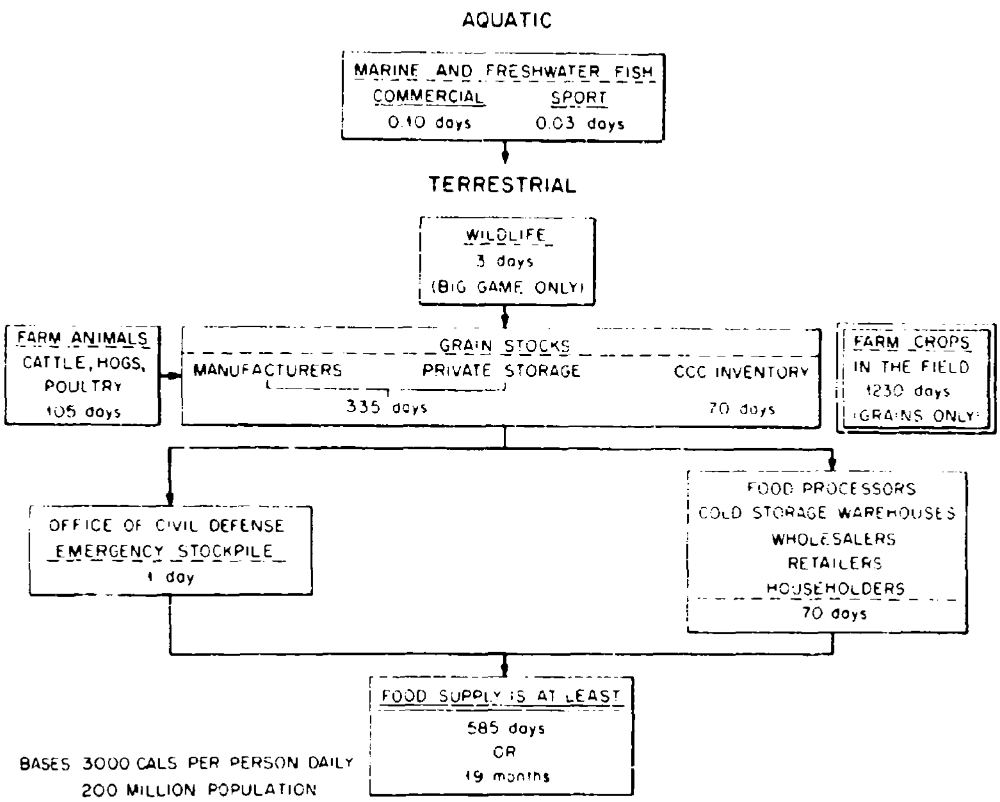


Fig. 1?.1. Estimated National Food Supply, July 1, 19?7.

This suggests that the bulk of the grain crop could be successfully harvested after the fallout associated with this attack. The total estimated national food supply is 585 days or 19 months, which is about 2 months and 4 months less than that of 1966 and 1965, respectively, when comparably calculated. The figure is a minimum one because the large amount of food in FARM CROPS is not included in the total.

Table I. Estimated Days of Food in the Form of Farm Animals, Grain Stocks, and Farm Crops in the Field (Grain Only) for July 1, 1967.

| FARM ANIMALS | | GRAIN STOCKS[5] | | | FARM CROPS |
|---|---|---|---|---|---|
| Cattle | 73 | Food | Wheat | 63 | 232 |
| Hogs | 29 | | Rye | 2 | 3 |
| Sheep | 2 | Feed | Corn | 233 | 632 |
| Poultry | 1 | | Oats | 15 | 44 |
| | | | Barley | 8 | 26 |
| | | | Sorghum | 47 | 111 |
| | | | Soybeans | 37 | 182 |
| TOTALS | 105 | | | 405 | 1230 |

## 18.3 CANADIAN GRAIN SURPLUS

The Canadian wheat, oats, barley, and rye supplies considerably exceed domestic use. It is likely that quantities usually destined for export would be available for purchase by the U.S. in an emergency. Indeed, it seems reasonable that the two countries would pool their grain stocks to the best mutual advantage. Canada produces annually somewhat more wheat than our domestic use. Their 1966-67 wheat exports were 518 million bushels (77 days for U.S. population, 3000 calories daily, 200 million population) and wheat, oats, barley, and rye together totaled

83 days.[6]

## 18.4 GEOGRAPHIC DISTRIBUTION OF FOOD STOCKS BY STATES

A summary of food stocks by states at mid-1967 was estimated from USDA sources.[3,7,8] Only 3 categories were used: grains, livestock, and processed food. The days of food in each category were calculated at 3000 calories daily for the present population of each state. The maximum and minimum figures in days for each category are listed in Table II.

Table II. Maximum and Minimum Days of Food by States.

| | GRAINS | LIVESTOCK | PROCESSED FOOD | TOTAL DAYS |
|---|---|---|---|---|
| Minimum | 0.3 (Maine, N.H., Vt., Mass., R.I., Conn.) | 4 (R.I.) | 30 (Conn., N.M., Nev.) | 34 |
| Maximum | 7244.0 (Nebr.) | 1144 (S.D.) | 229 (Idaho) | 8136 (Nebr.) |
| Ratio (Maximum to Minimum) | 24000 | 290 | 7 | 220 |

The geographic distribution of food stocks is shown on the map in Fig. 2. The grain stocks are generally stored near the area of production and hence large supplies of grain occur in the northern central states. Likewise, much livestock is fed and ranged in these states and consequently large stocks of feed grains are on hand and yield large food stocks relative to population. The processed food category is made up of home-retail-wholesale stocks which are relatively similar on a per capita basis in each state,* and stocks which are ready to eat virtually as harvested,

*Processed food stocks vary from 23 days in Maryland and New Mexico to 39 days in North Dakota.

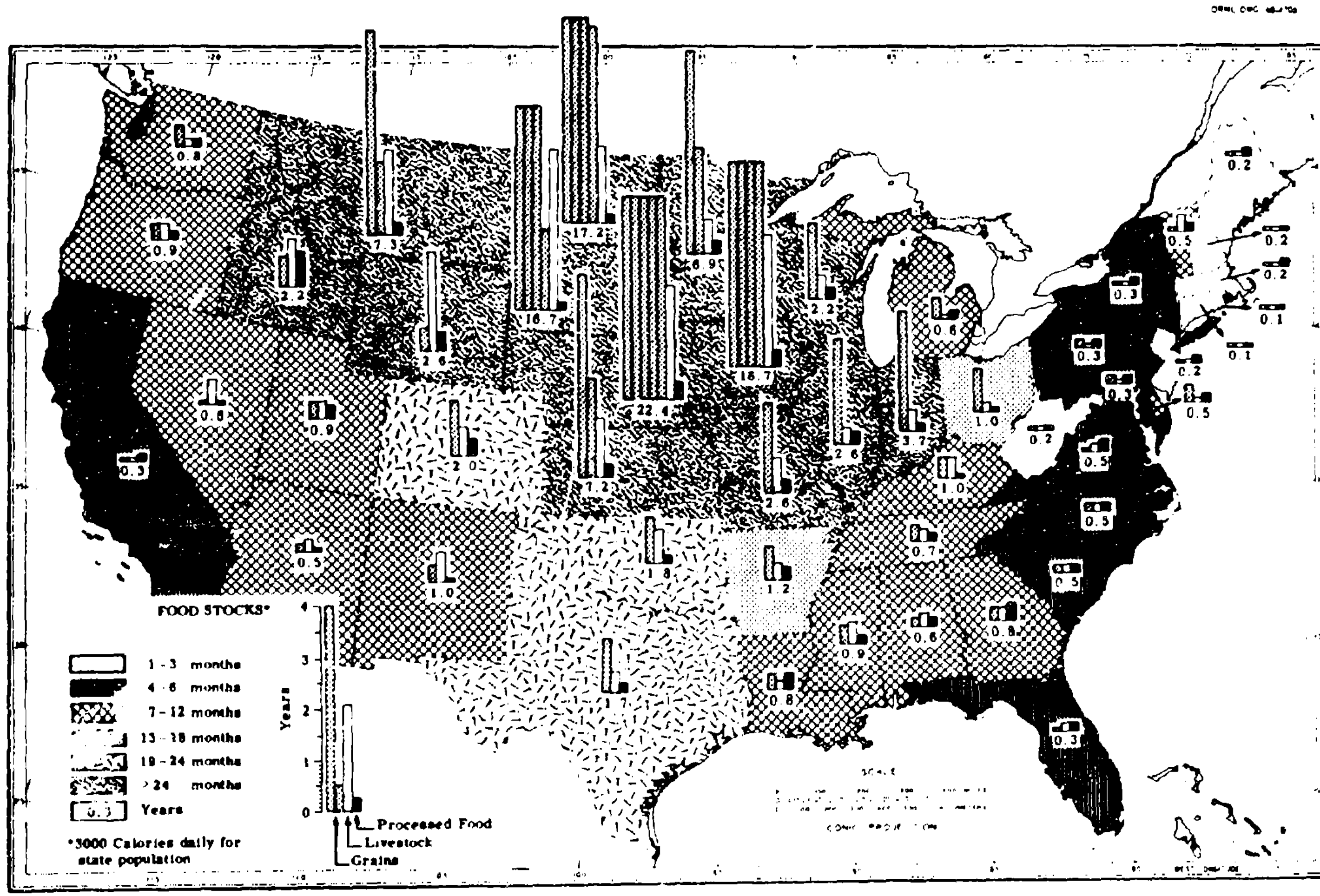


Fig. 13.2. Quantity of Food Stocks by States, July 1, 1957.

e.g., potatoes in Maine and Idaho, peanuts in Georgia, dried edible beans, and cane and beet sugar and other sweetenings. The bar graphs in each state clearly show the unequal distribution of food stocks across the nation. The states of New England, the Northeast, Atlantic, Southeast, Southwest, and far Northwest have less than one year of food stocks, whereas the grain states from Montana to Indiana have more, usually much more, than two years of food stocks. Nebraska, with 22 years of stocks, has the largest amount for its population, closely followed by Iowa with 19 years, and North and South Dakota each with 17 years of food stocks.

The per cent composition of the stocks by states is depicted in the triangular graph of Fig. 3. The state of New York has 31% of its calories in grains, 14% in livestock, and 55% in processed foods. The balance is closest of any state to that of the current U.S. food consumption pattern marked by the star at 21% grains, 18% livestock, and 61% processed foods.[9] Zip code abbreviations are used for the states. Those states with solid symbols have more than a year's food stocks, and those with line symbols have less than a year's stocks.

From these two figures some obvious recommendations for emergency food provisioning can be made. New Jersey, the New England states, Florida, and West Virginia have small supplies of food on hand concurrent with a low per cent of stocks as grains. It would seem prudent to store enough grain in non-target areas of these states to assure feed for livestock and humans. This would prevent the decimation of livestock herds or allow use of the livestock and the stock feed in the event of lack of transportation for distributing grains from areas of surplus to areas of deficit.

## 18.5 STRATEGIC COMMODITY RESERVES

### Food and Fiber for the Future

In July 1967, the long-awaited report of the President's National Advisory Commission on Food and Fiber appeared.[10] The commission made a long-range appraisal of U.S. agricultural and foreign trade policies and studied the effects of the policies on the U.S. economy and its

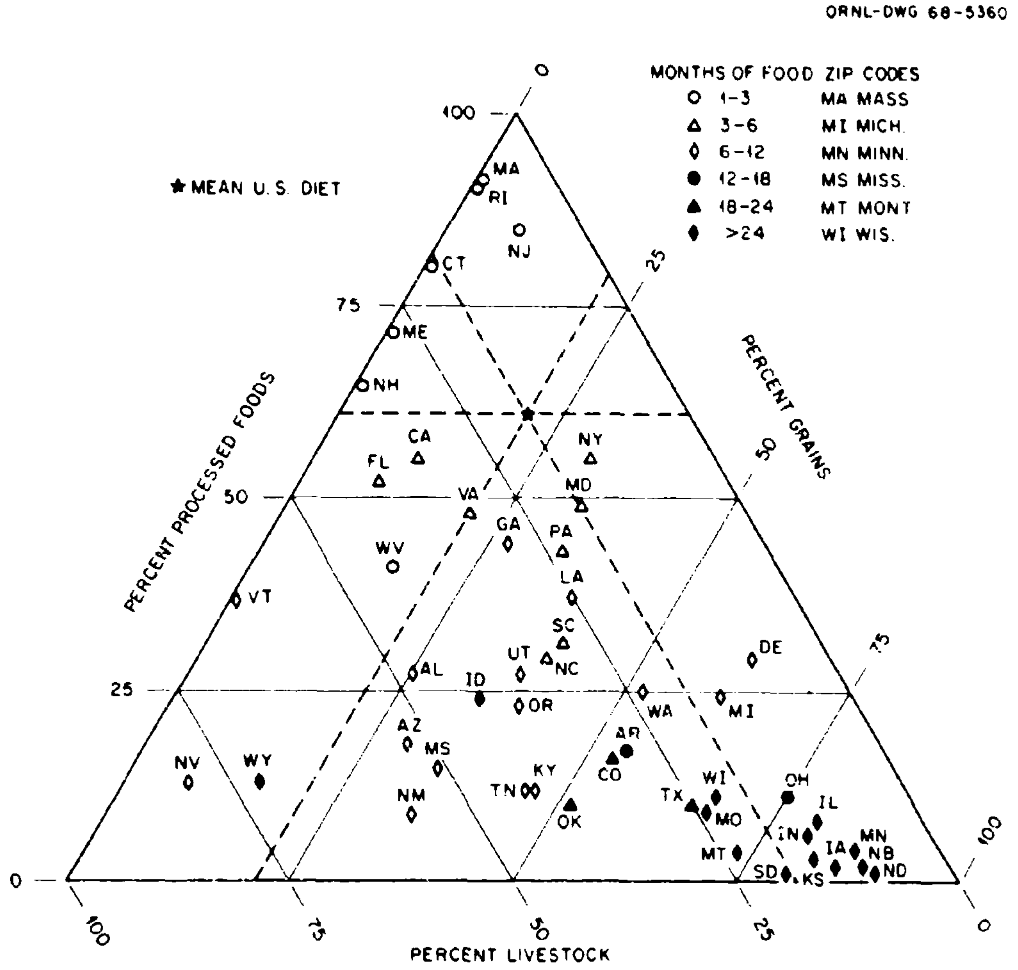


Fig. 18.3. Per Cent Composition of State Stocks of Foods.

foreign relations.

The portion of the report which is important for its civil defense implications is the 11 pages which deal with carryover and reserve policies for agricultural commodities. Two quotations set forth the conclusions of the majority of the Commission members: 1. "The Commission recommends establishment of a national security or strategic reserve, including emergency stocks for food aid. This reserve should be isolated from the market except as offsetting sales and purchases are required to maintain the quality of the reserve stocks."[10, p.22] 2. "The majority of the Commission recommends a program for adjusting carryover stocks of major storable farm commodities in order to maintain reasonable stability of available supplies of those commodities."[10, p. 23]

There has never been a specific emergency food reserve policy, for past policies were income-oriented. The stocks acquired by the Commodity Credit Corporation of USDA "depended primarily on price stabilization policies rather than on a carefully-defined set of requirements for emergency use."[10, p. 96]

Hearings on proposals for a strategic agricultural commodity reserve program were held in August and October 1967 in the House of Representatives with six bills under consideration.[11] In January 1968, hearings were conducted on three Senate bills on commodity reserves.[12] It was brought out in these hearings that a study by Frederick V. Waugh of the USDA at the Commission's request indicated that reasonable total carryover objectives would be: 550 to 650 million bushels of wheat, 35 to 45 million tons of feed grains, 10 to 12 million hundred weight of rice, and 5 to 6 million bales of cotton.[12, p.10] The amounts approximate the annual domestic use for wheat and 29% of annual domestic use of feed grains.[13] In February 1968, President Johnson strongly endorsed the establishment of a commodity reserve, calling it a Security Commodity Reserve or National Food Bank.[14] He pointed out that legislation to establish a Security Reserve of wheat, feed grains, and soybeans had been introduced in 1967.

Some legislators are enthusiastic about a Commodity Reserve because its creation will raise prices for farmers who are much in need of such

help now. Other legislators do not favor it because they see it as only a temporary boost in price.

From the standpoint of civil defense it makes good sense to establish carryover and reserve stocks and to decide their best locations on a scientific basis according to reserve needs instead of price needs. Moreover, such a program would likely have a salutary effect on price stability because the program would be explicit and known to all well in advance. Although the appropriate levels for carryovers would best be set by the government, it seems risky to have a carryover of less than a full year's food supply on the bases used for Fig. 1. Soybeans should be included in the Strategic Commodity Reserve because in combination with grain they can provide a protein almost as good as meat in the event of a reduction in livestock.[15]

Senator Karl Mundt has introduced a wheat and soybean reserve bill (S.3156) which would set the reserve levels at a specified percentage of the estimated export and domestic utilization figures. For wheat, the level would level would be 20%; for feed grains, 15%; for soybeans, 6%.[16] Senator Ellender, chairman of the Senate Agriculture and Forestry Committee, has recently announced his opposition to national reserve stocks of wheat, feed grains, and soybeans as too costly and of no permanent help for farmers.[17]

The ferment of activity and inquiry subsequent to the release of the report of the NACFF appears useful to civil defense. The suggestions in the report have initiated serious inquiry into the determination of what carryover levels of commodities are actually needed. Civil defense needs may be much more clearly defined as a result.

## 18.6 POST ATTACK TRANSPORTATION AND DISTRIBUTION OF FOOD

The geographic location of food stocks shown in Fig. 2 shows strikingly how much we would be dependent upon postattack transportation for their movement to areas of need. The rapidly moving change from farming → an agricultural industry → an agri-business is much more than mere semantics. Deeply involved in this change--and very possibly a prime mover in it--is the ready availability of rapid transportation and new patterns of

marketing and distribution which depend on it. Almost every trend in distribution and marketing has made us more dependent on prompt, fast transportation. The meat packing industry has emphasized this dependency by pointing out that the average pound of meat travels ~ 1000 miles between supplier and consumer. Such developments make postattack distribution of food more vulnerable.

Published studies of the effects of nuclear attacks on truck transportation,[18] railroad transportation,[19] freight transportation systems,[20] food processing and distribution,[21] and food availability and accessibility,[22] suggest that adequate facilities remain for servicing the surviving population. But would such a conclusion hold true if millions more people are saved by advanced strategic defense measure such as combination fallout-blast shelters and antiballistic missile defense?

The proportional share of products moved by rail, truck, and waterway has changed considerably since the dates of published data used for the studies. With respect to agriculture, at least, the changes[23] have been sufficient to require an entirely different USDA-developed method to estimate the cargo transportation tonnage by commodity and carrier.

In view of our extreme dependence on transportation for the postattack agricultural and food industries a thorough review of our needs--including necessary petroleum products for transportation--is in order.

## 18.7 VULNERABILITY OF THE TERMINAL GRAIN ELEVATOR SYSTEM

Terminal elevators play a key role in the grain marketing system. Harvested grain passes from farmer → country elevator → terminal elevator from which it is sold to processors, distillers, feed manufacturers, exporters and others. The terminal elevators are in the principal grain-marketing centers (e.g. Chicago, Duluth, Indianapolis, Kansas City, Minneapolis, Omaha, St. Louis) and hence are more vulnerable than the country elevators which are located among the grain-producing farms.

There were 650 terminal grain elevators and ~ 7650 country elevators in 1963.[23, pp.218-219] The 1967 storage capacity of a sample of 553 terminal elevators in 35 states was 1,854 million bushels or 33.8% of the total 1967 off-farm storage capacity.[24]

Estimates of the losses of terminal grain stocks were made from the 3600 megaton NRAC UNCLEX attack and the 9000 megaton Martin-Latham* attack.[25] A worst-case approach was taken, i.e., grain elevators at targeted cities were assumed to be a complete loss. The locations of the elevators in the sample are plotted in Fig. 4 and several elevators may be represented at a symbol. Those elevators in target cities are shown as black discs. A summary of the results of the two attacks is given in Table III.

Table III. Results of the Unclex and the Martin-Latham Attacks for 553 Terminal Grain Elevators

| | UNCLEX | MARTIN-LATHAM |
|---|---|---|
| No. elevators at risk | 165 | 204 |
| No. target cities in sample | 61 | 79 |
| Bushels capacity, 1000 | 674 | 847 |
| % sample terminal capacity at risk | 36 | 46 |
| % Population loss | 51 | > 55 |

The relative invulnerability of the grain storage should be clear from the following discussion. The 36% loss of sample terminal elevator capacity is surely much higher than for country elevator capacity because most of the latter are remote from targets. Even if this figure is used as the loss for U.S. grain stocks in all positions in the UNCLEX attack, survival of grain stocks at ~ 64% is much in excess of population survival at 49%. Moreover, the heavy Martin-Latham attack does not change this las conclusion because ~ 54% of grain stocks would survive compared with a population survival of < 45%.

*The attack was targeted for 303 cities which would be likely targets by reason of their population, industry, or military bases.

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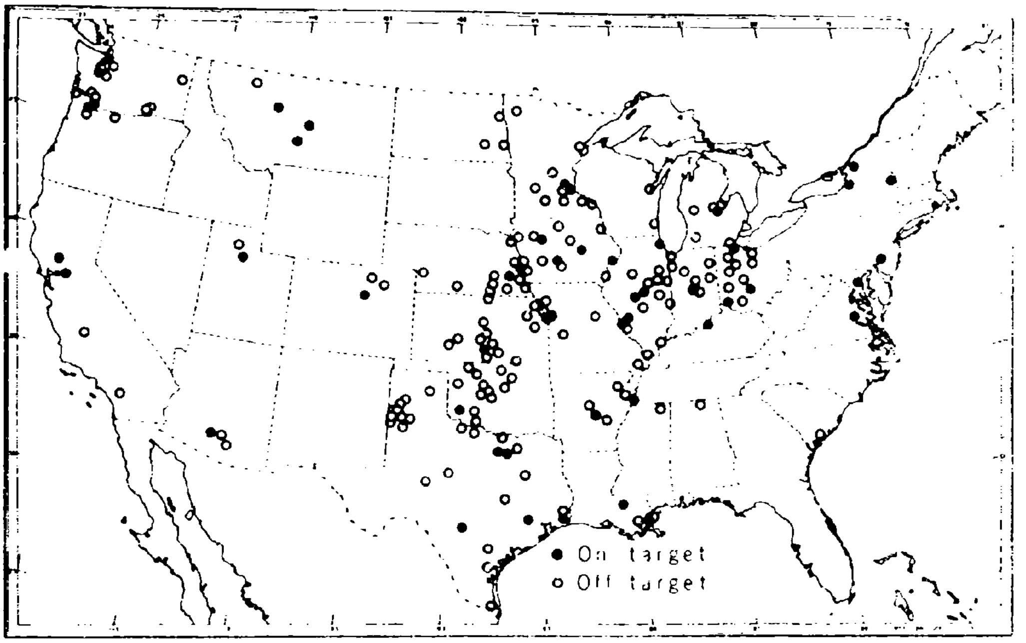


Fig. 1[illegible].[illegible]. Terminal Grain Elevators UNCLEX Attack.

The vulnerability of the population is, of course, based on present protection (no Anti-Ballistic Missile defense, no advanced Civil Defense such as underground blast shelters) and any optimism regarding the relative invulnerability of grain and the consequent adequacy of supply for the surviving population is equivalent to pessimism regarding the present defense system for survival of the population.

At midyear, the loss of food grains in an attack would be proportionally higher than that of feed grains because two-thirds of our wheat and rye is in the more vulnerable off-farm storage whereas the reverse is true for feed grains as shown in Table IV.

Table IV. Grain Storage, July 1, 1967

| | TOTAL | | FOOD GRAINS (Wheat, Rye) | | FEED GRAINS (Corn, Oats, Barley Sorghum, Soybeans) | |
|---|---|---|---|---|---|---|
| | On Farms | Off Farms | On Farms | Off Farms | On Farms | Off Farms |
| % | 43 | 57 | 34 | 66 | 66 | 34 |
| Days | 176 | 229 | 22 | 44 | 224 | 115 |

## 18.8 SOURCES OF PROTEIN ALTERNATE TO LIVESTOCK

Our livestock is vulnerable to a biological attack. Although our peace-time preparation to handle outbreaks of livestock disease is adequate,[26] it is doubtful that widespread disease could be controlled in the period following nuclear attack.

The extreme difficulty of coping with the viral foot-and-mouth disease has been accented by the recent outbreaks in England and Botswana.[26,27] An oral report by a U.S. veterinarian called to help in the outbreak in England pointed out that even with our experience in

eliminating the disease in Mexico (1946-1954) we have underestimated the amount of equipment needed.[28] For example, in only one of the 12 FMD control centers set up by the British, 70 bulldozers, 70 diggers, 40 trucks, and 6 fire engines were required for the operations!

From the foregoing it is obvious that plans for use of alternate sources of protein should be developed. I believe that lysine-fortified grain would make a good alternate source of protein. For this reason, lysine logically belongs in a strategic commodity reserve as a hedge against a livestock shortage. The amount needed to fortify the ~ 500 million-bushel domestic wheat consumption for food would cost $30 million. Put in a different frame, a family of four consumes about 600 pounds of flour and cereal products annually. They could purchase enough lysine to enrich this annual cereal diet for less than three dollars.

## 13.9 THE USDA DEFENSE BOARDS

The USDA Defense Board system is comprised of representatives of those USDA agencies which have defense emergency responsibilities. The system is hierarchic with a national board, 8 regional boards, 50 state boards, and ~ 3000 county boards. It would be their responsibility in an emergency to assess the food situation and to implement the post-attack food plans which have now been developed for each state. Since the system reaches to our counties, and is there composed of local representatives who are well acquainted with problems peculiar to their area, it should function effectively.

State and County Defense Boards have their own Defense Operations Handbooks which they have used to complete five readiness exercises dealing with nuclear attack effects on agriculture. The most recent one was completed in March 1968. It used the CIVLOG-65 (Civilian Logistics) attack of 1995 megatons aimed mostly at military targets. Such an exercise requires familiarity with the terminology of nuclear warfare and its effects and is an excellent training procedure. The County Defense Board reports of the CIVLOG-65 attack were evaluated by their respective State Defense boards for rural fire damage, the food situation, agricultural production and non-food requisities, and timber

resources. Additionally, each State Defense Board prepared a report of the main actions it would probably have taken during the first month of the postattack period. Summaries of the reports will be made later in 1968 and should reveal the potential effectiveness of the boards in carrying out their missions.

## 18.10 RECOMMENDATIONS

In view of the probable saving of lives because of advanced strategic defense measures of the future, the following items are recommended.

1. Adopt the recommendations of the National Advisory Commission on Food and Fiber for establishing a strategic commodity reserve and for adjusting carryover stocks of major farm commodities.
2. Include lysine amino acid in any strategic commodity reserve program.
3. Develop criteria for locations of stocks of major food commodities in safe storage near population centers.
4. Develop estimates of consumer demand for use in determining the adequacy of postattack fuel and transportation for the distribution of food. Perhaps a joint effort of the departments of Commerce, Transportation and Agriculture would be possible.
5. The State and County Defense Boards should evaluate a high level general nuclear attack somewhat like the NRAC UNCLEX attack for its effects on agriculture with special attention to transportation and distribution. Even a cursory evaluation might well point out difficulties for which answers can be suggested.

## 13.11 REFERENCES


1. A. F. Shinn, "United States Food Supplies -- Grains," Annual Progress Report, Civil Defense Research Project, March 1965 - March 1966, ORNL-TM-1531, p 37(Fig. 2.3).

2. A. F. Shinn, "Grain Stocks and Protein Supplies," Annual Progress Report Civil Defense Research Project, March 1966 - March 1967, ORNL-4184, Part I, p 26(Fig. 1.1).

3. Livestock and Poultry Inventory, January 1, LvGn1(63), p 1, Statistical Reporting Service, USDA(Feb. 13, 1963).

4. Crop Production, CrPr 2-2(10-67), p 2, Statistical Reporting Service, USDA(Oct. 10, 1967).

5. Stocks of Grains in All Positions, GrLg 11-1(7-67), p 1, Statistical Reporting Service, USDA(July 24, 1967).

6. Canadian Grains: Supply and Distribution in Canada of Wheat, Oats, Rye and Flax Seed, 1962-68, Grain Market News, 15, 6(Sept. 8, 1967).

7. Stocks of Grains in All Positions, GrLg 11-1(10-67), Statistical Reporting Service, USDA(Oct. 1967).

8. R. M. Walsh et al., Food Supplies Available by Counties in Case of a National Emergency, A Civil Defense Study, USDA, Agricultural Economic Report No. 57(July 1964).

9. U.S. Food Consumption, Supplement for 1965 to Statistical Bulletin No. 364, p 17(Table 36), Economic Research Service, USDA.

10. Sherwood O. Berg, Chmn., National Advisory Commission on Food and Fiber, Food and Fiber for the Future, Washington, D. C., pp 22-24, 73-77, 98-100(July 1967).

11. Strategic Agricultural Commodity Reserve Program, Hearings before the Subcommittee on Livestock and Grains of the Committee on Agriculture, House of Representatives, 90th Congress, 1st Session on H.R. 9644, H.R. 11235, H.R. 11436, H.R. 12067, H.R. 12103, and H.R. 12166. August 7, 9, 10, 15, 21, and October 31, 1967. Serial DD, U.S.G.P.O., Washington, D. C. iv + 177 pages.

12. Commodity Reserves, Hearings before a Subcommittee of the Committee on Agriculture and Forestry, United States Senate, 90th Congress, 2nd Session on S. 2553, S. 2617, and S. 2743, Jan. 30 and 31, 1968. U.S.G.P.O., Washington, D.C. iv + 152 pages.

13. Feed Situation, FdS-222, p 6, Economic Research Service, USDA(February 1968).

14. Message from the President of the United States Transmitting a Message Relating to Agriculture, 90th Congress, 2d Session, House of Representatives, Document No. 267, 12 pages(February 27, 1968).

15. N. S. Scrimshaw, World Population and Food Supplies, 1980, Amer. Soc. Agronomy Publication No. 6, p 36, rev. 1965.

16. New Senate Bill Aimed at Soybean, Feed Grain Reserves, Feedstuffs, 40, 2 (March 23, 1968).

17. Senator Ellender Says Grain Reserve Won't Help Farmers, Feedstuffs, 40, 8 (March 30, 1968).

18. Stanford Research Institute, The Effects of Nuclear Attack on Motor Truck Transportation in the Continental United States, Project No. 3711-400, Menlo Park, Calif. (January 1963).

19. Harvey L. Dixon, Dan G. Haney, and Paul S. Jones, A System Analysis of the Effects of Nuclear Attack on Railroad Transportation in the Continental United States, SRI Project No. IU-3084, xiii + 254 pages, Stanford Research Institute, Menlo Park, Calif. (April 1960).

20. Harvey L. Dixon and Thomas H. Tebben, Effects of Nuclear Attack on Freight Transportation Systems: Interactions and Comparisons Among Modes. SRI Project MU-4949-150, v + 47 pages, Stanford Research Institute, Menlo Park Calif. (March 1967).

21. John W. Billheimer and Harvey L. Dixon, Analysis of Postattack Food Processing and Distribution, Progress Report, SRI Project No. IMU-4021, xi + 120 pages, Stanford Research Institute, Menlo Park, Calif. (June 1964).

22. John W. Billheimer, Postattack Food Availability and Accessibility--A Case Study, Final Report, SRI Project MU-5576, viii + 140 pages, Stanford Research Institute, Menlo Park, Calif. (April 1967).

23. Agricultural Markets in Change, Marketing Economics Division, Economic Research Service, USDA, Agricultural Economic Report No. 95, Chapter 4, Transportation in Agricultural Marketing, pp 86-111, by Transportation Economics Group.

24. UGSA Terminal Warehouse Capacity and CCC-owned Storage Inventories as of September 30, 1967, and December 31, 1967, Agricultural Stabilization and Conservation Service, Kansas City Data Processing Center, K.C., Mo. (March 22, 1968).

25. T. L. Martin, Jr. and D. C. Latham, Strategy for Survival, pp 182-190, University of Arizona Press, Tucson (1963).

26. Hon. Richard Bolling, Department of Agriculture Watching Foot-and-Mouth Disease Overseas, Congressional Record, E236-37 (January 25, 1968).

27. Botswana Fights Foot-and-Mouth Disease, Foreign Agriculture, 5, 13 (November 27, 1967).

28. Walter Eskew, D.V.M., Report on Foot and Mouth Disease, Tennessee USDA State Defense Board Meeting, Nashville, Tenn., March 1[illegible], 1[illegible].

# 19. VULNERABILITY OF LIVESTOCK IN THE LIVESTOCK INDUSTRY

S. A. Griffin*

This phase of the general study of food resources is concerned with the vulnerability of livestock and the livestock industry to nuclear attack. The importance of livestock products to the American diet, the potential food reserve represented by livestock and the size of the industry have been pointed out in previous reports.[1]

In considering the vulnerability of livestock, it is necessary to know what facilities are available on farms and ranches for the sheltering and protection of livestock as well as livestock and livestock products in marketing channels. For minimum cost, protection programs should be based on the maximum utilization of existing facilities rather than the development of new facilities. Some degree of modification of facilities can be accomplished, especially in those situations where new facilities are being developed or existing facilities are being remodeled.

Since very little data is available in the literature concerning the protection available on farms for livestock a cooperative program was developed with the Tennessee Office of the Statistical Reporting Service (SRS) of the U.S. Department of Agriculture. This program was designed to be carried out as a pilot study in Tennessee and to test the questionnaires which could be used on a national basis at a later date. The survey was taken in conjunction with the SRS annual enumerative survey of livestock inventories between November 22 and December 2, 1967. The completed questionnaires were obtained by SRS and returned to ORNL for summary and analysis.

The scope of the survey in terms of the number of questionaires envolved, the numbers of livestock and the size of the farms is presented in Table I. The geographic distribution of the farms sampled is shown in Figure 1. In reporting the results of the survey those farms with less than ten head of livestock and/or less than ten acres of land were not considered as a part of the commercial livestock

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Table I: Scope of Survey

| | | |
|---|---|---|
| Total questionnaires | | 205 |
| Questionnaires used | | 111 |
| Questionnaires not used (less than 10 head of livestock and/or 10 acres land) | | 94 |
| Average size of farm | | 173.4 acres |
| | Range: | 10-1000 acres |
| Total number of barns | | 206 |
| Total number cattle and calves all ages | | 4,330 |
| Total number hogs and pigs all ages | | 1,791 |
| Average number of livestock on farms | | 52 |
| | Range: | cattle 0-292 |
| | | hogs 0-243 |

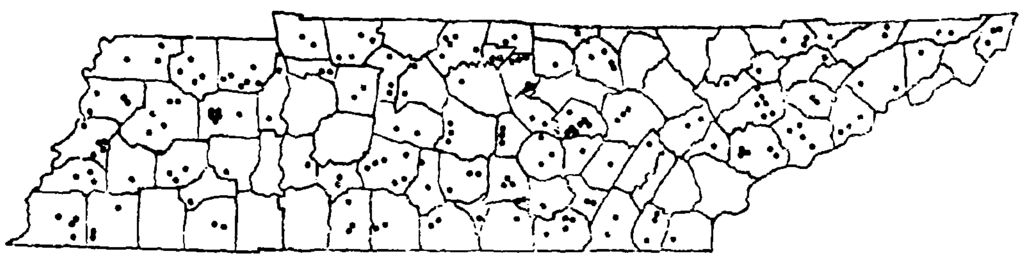


Fig. 19.1. Location of Farms in Sample.

industry. The sampling procedure followed in the Tennessee survey was the method followed by the Statestical Reporting Service of the USDA for their enumerative surveys. This procedure is based on the cooperation with the USDA and the Bureau of the Census. In this program all states and counties were divided into units based on total land area, acres of cropland and dollar value of agricultural production. These Units were divided into two segments and two adjoining units were combined to make a cluster of four segments. One segment from a cluster is sampled each time and segments sampled within a cluster are rotated every five years. A random sample of clusters is used for survey purposes. The sample used for this survey of protection available for livestock in case of nuclear attack was the same as the sample used for the USDA enumerative survey of livestock numbers.

## [illegible].1 AVAILABLE PROTECTION ON TENNESSEE FARMS

The protection available for livestock is summarized in Table II. Protection factors for the barns were calculated according to the procedures and supporting data published in the Rural Shelter Handbook.[2] The livestock barns available on farms would house [illegible] percent of the hogs and [illegible] percent of the cattle and would provide an average protection factor of 1.5. This level of protection would be inadequate in case of a moderate to large nuclear attack against the U.S. However, if we assume radiation does of a magnitude of [illegible] to 1000 rads the level of protection could mean the difference between lethal and sublethal exposure. This level of protection does leave livestock in a vulnerable position.

The data obtained in this survey indicate that larger portions of the livestock could be sheltered than was indicated by a USDA survey taken in 1962[3] concerning only dairy cattle. Thirty-four percent of the dairy cattle in the southeastern states could be sheltered as compared to [illegible] percent of all cattle in this survey.

These protection factors would be considered a worst case situation as they do not consider ground roughness and assume an empty barn as far as animals are concerned. Any irregularities in ground surface which would allow fallout particles to fall below the surface would

Table II: Protection--Food and Water Available on Farms

| | |
|---|---|
| Average number of livestock barns per farm | 1.85<br>Range: 0-8 |
| Average protection factor for barns | 1.8<br>Range: 1.0-5.4 |
| Percent of livestock that could be sheltered | |
| Cattle | 86.7 |
| Hogs | 70.8 |
| Percent of barns with hay stored above livestock | 52.0 |
| Percent of barns with water available in the barn | 24.0 |
| Feed supply stored on farm, under cover (days) | 98.9<br>Range: 0-540 |

provide some mass thickness between the radiation field and the animals and thus reduce the level of radiation reaching the animal. This factor would be variable from barn to barn. If the barns were filled with animals they would provide mutual shielding for each other. This would vary with the size of the barn and the number of animals.

The supply of feed and water available on farms is an important factor in considering a post attack situation which would probably put transportation of livestock feeds at a low priority. The feed stored on farms will vary with the time of year in relation to harvest season and feeding periods with the greatest supply available in late fall. In the present survey taken in late November and early December the average feed stored would take care of the animals on the farms for almost 1[illegible] days. Twenty-four percent of the barns in this study had water available in the barn but this water would be dependent on electric power for pumping. This indicates that water may be a more acute problem in the immediate post attack situation than feed. Livestock can survive for some time without feed but they will not be able to survive more than a few days without water. Thus the livestock that could be sheltered in an emergency might need to be released to obtain water while radiation levels were still too high for safe movement of humans and animals. It is interesting to note in this context that only one farm in those surveyed had an auxillary electric generator.

In addition to the availability of shelter the time required to move livestock to shelter is also an important factor. The time, estimated by the farmers, needed to move livestock to shelter is summarized in Table III. About fifty percent of the livestock could be moved to shelter in two hours and about seventy-five percent in three hours. The number of livestock on the farm did not appear to affect the time required to move them to shelter as much as the organization of the farm.

The majority of livestock barns in Tennessee are of wood frame or pole construction with wood or corrugated metal siding. The roofs are mainly corrugated metal with some asphalt roofing. Livestock facilities that are being built at the present time are mainly of pole type construction with corrugated metal siding and roof. These facilities are

Table III: Estimated Time (by farmers) Required to Move Livestock to Shelter

| | 1 hour | 2 hours | 3 hours | 4 hours | > 4 hours |
|---|---|---|---|---|---|
| Percent of cattle in survey | 30 | 53 | 73 | 78 | 87 |
| Percent of hogs in survey | 50 | 60 | 70 | 71 | |

designed for maximum use of equipment for materials handling and minimum labor, with hay at ground level and grain and silage in bins and silos that can be mechanized.

## 15.2. VALUE OF AVAILABLE PROTECTION

The value of a protection factor of 1.[illegible] for cattle under an UNCLEX attack was next estimated. The details of the UNCLEX fallout patterns in Tennessee are shown in Figure 2. Using a midlethal value of 550 roentgens for the maximum four-day dose values given in Figure 2, it was estimated that 33% of Tennessee cattle (the total cattle population on January 1, 1963 was 2.3 million) would die by the end of thirty days. If the protection factor were unity (no protection) 60% would die. Since hogs have a higher resistance to radiation than cattle, fewer would die in both cases.

The savings of 600,000 cattle with such a low P.F. encouraged us to examine the value of low protection factors in general. The results of the study are shown in Figure 3 together with the lethality curve used for the calculations. It can be seen that up to ninety per cent of the cattle in Tennessee could be saved by a protection factor near 10 (with little value from higher P.F.'s), but that 80% of all cattle that can be saved by fallout protection alone are saved by a protection factor of only 3.2.

Inasmuch as most barns available for sheltering livestock in case of nuclear attack do not provide adequate protection some alternatives that would be feasible to the farmer should be considered.

Since the level of protection from radiation is dependent upon the mass thickness of the material separating the animals from the radiation field some additional protection can be obtained by placing a mound of dirt around the barn. If the mound was 4 feet in height and reasonably uniform in thickness and the entrance protected by sand bags the protection factor could be increased from about 1.5 for a pole barn to about 5.5. An illustration of this procedure is given in the following examples (Figures 4 and 5). Plans illustrating this procedure have been distributed by USDA through the Federal Extension Service and the various State Extension Services.

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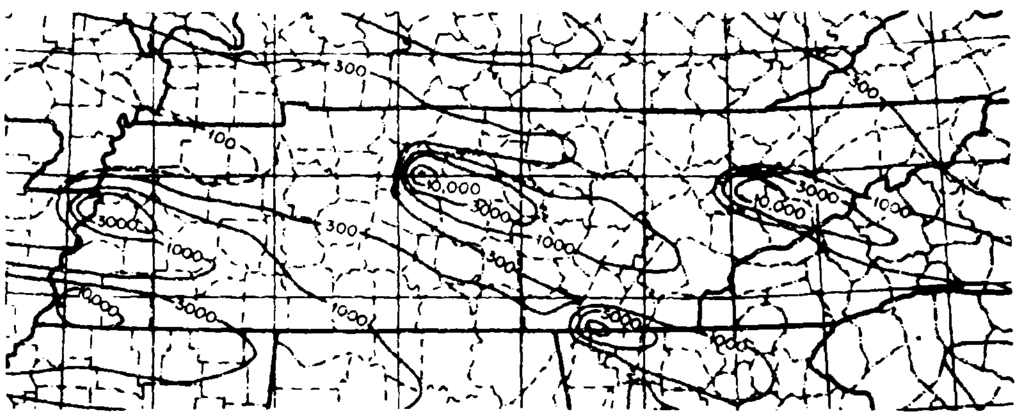


Fig. 19.2. Details of UNCLEX Isodose Contours for Tennessee (Numbers Represent Four-Day Maximum Dose—Roentgens).

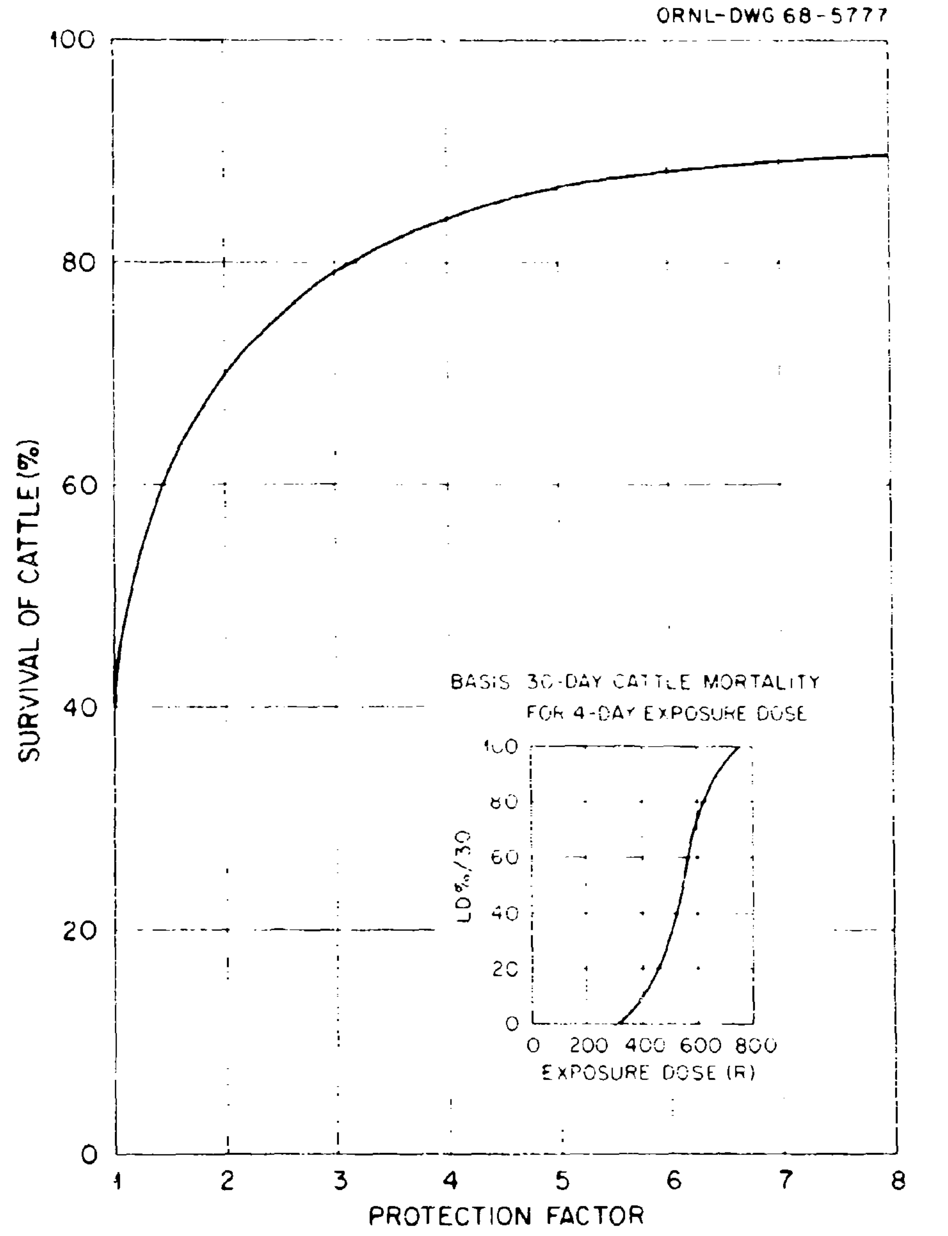


Fig. 1?.3. Effect of Protection Factors on Cattle Survival in Tennessee. (UNCLEX Attack, 30 Days Post Attack).

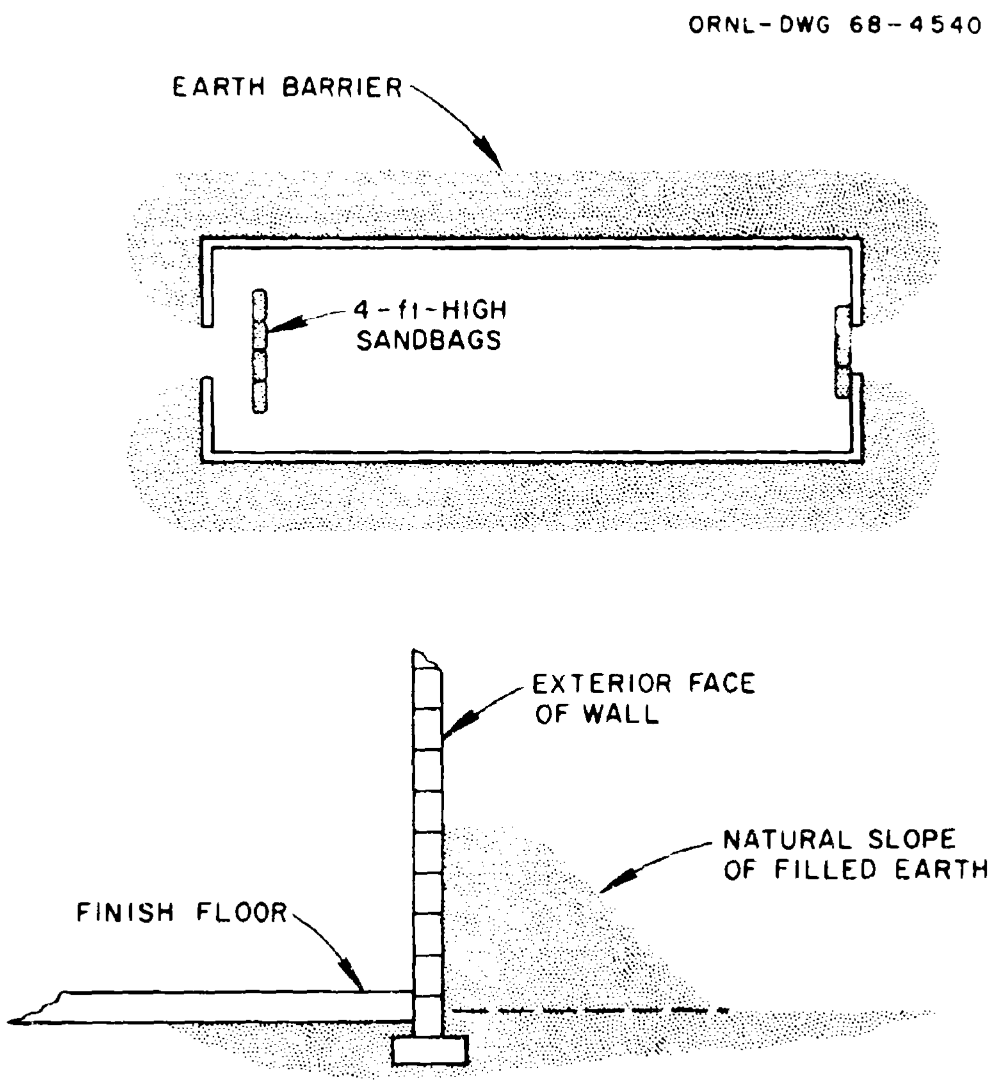


Fig. 19.4. Mounding Earth Around a Barn With Masonry Walls.

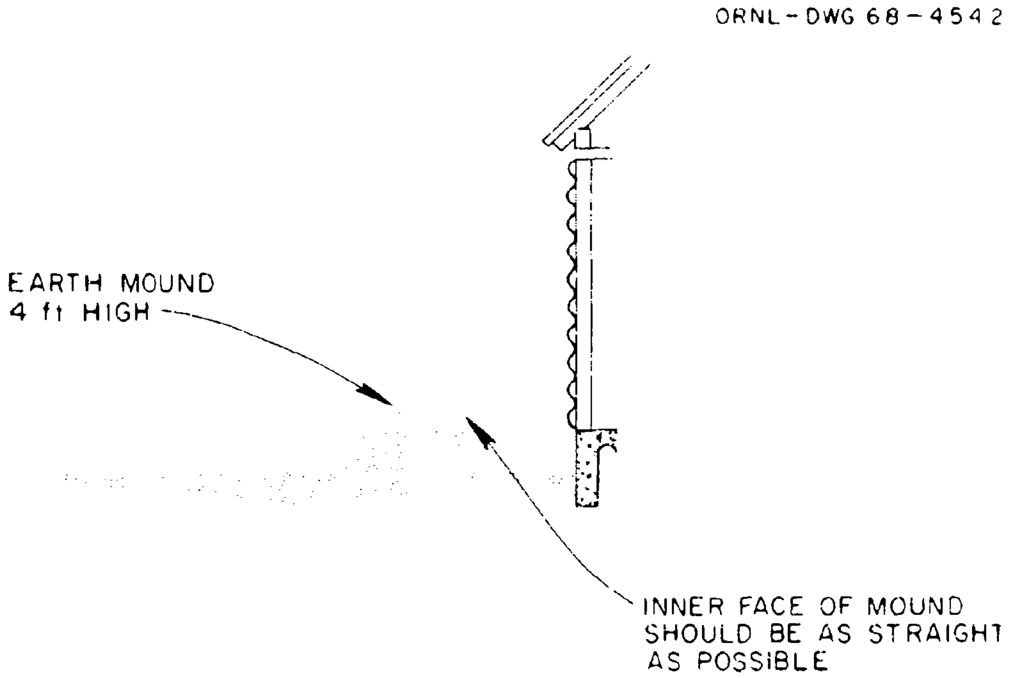


Fig. 19.5. Mounding Earth Around a Barn with Frame or Pole Construction.

## 19.3. REFERENCES


1. Annual Progress Report, Civil Defense Research Project, March 1966-March 1967 ORNL-4184, Part (1967), pp. 41-53.

2. Rural Shelter Handbook - Texas A & AM University, Texas Agricultural Extension Service, College Station, Texas.

3. Fallout Facilities and Fuels on Farms in 24 Central and Southern States - USDA - SRS-3 1962.

4. Protecting Family and Livestock from Nuclear Fallout -

# 20. COST OF CONVENTIONAL FOOD AS AN ITEM IN A FOOD RESERVE PROGRAM

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## 20.1 INTRODUCTION

The required amount of protection against the risk of starvation in the case of a national emergency is difficult to assess. It is both and inseparably a moral and economic question facing the nation and every member of our society. Any food reserve program will be governed to a large extent by the cost factor. The cost of a food reserve program is primarily a function of the type of foods to be held in reserve stocks, the amounts of food to be held per capita, and the geographic concentration or dispersion of these stocks.

This study is concerned with the economic alternatives of holding emergency food stocks. Conventional and unconventional foods and the location of these stocks are to be considered. However, the purpose of the initial phase of the study reported here is to investigate the cost of establishing and maintaining a stockpile of the usual types of processed foods. The next phase will consist of an analysis of the use of unconventional foods.

## 20.2 PROGRAM CONTENTS

A diet composed of the usual food items which the American consumer is accustomed to eating can be considered as an extreme on the continuum of alternatives relating to the establishment of an emergency food reserve program. In the event of an emergency this program requires very little sacrifice in the food consumption habits of the population. The primary program restriction would be that highly perishable foods must be canned or dehydrated for storage.

Cost estimates of the food are based on 1969 wholesale prices.[1] Surveillance cost was calculated on the basis of a charge of $10 per lot for each inspection. This estimate was approximated from fees charged by the Federal Consumer and Marketing Service. It was assumed that short

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shelf life foods would be inspected twice a year, while other food items would receive one inspection per year. The storage stability or shelf life of the food items was based upon studies conducted by the Georgia Experiment Station, U.S. Department of Agriculture, technical reports, and correspondence with private industries.[2,3,4,5] Storage and handling charges are based on storage rates paid in 1965 to commercial warehouses by the Commodity Credit Corporation on processed food items held in its inventory.[6]

A relatively rich and varied diet for emergency use is presented in Table I. The food supplies included in this diet are capable of providing one person 3000 calories per day for one year. The supply of protein, calcium, thiamine, riboflavin, and niacin meets the recommended allowances established by the National Academy of Sciences.[7] However, the level of vitamin A and ascorbic acid is less than the recommended allowances.

The total cost for the establishment and maintenance of this program for one year is approximately $186 per person. Therefore, to launch a program of this magnitude for a population of 200 million would require expenditures in the excess of $37 billion dollars. The initial cost of this program for a population of 200 million makes it unrealistic. However, adjustments to any lower level can be made according to food intake level, the length of the expected emergency, and the estimated number of individuals to be fed.

One important variable in the maintenance cost of this program is the rotational outlets available for the food taken out of storage (that is, the value of the food for re-sale). Consideration is given in the next section to the possibility of rotating food items through the normal channels of trade, into animal foods, and other outlets.

Table I. Proposed Diet Consisting of Conventional Foods--Wholesale and Storage and Handling Cost of Providing [illegible] C/Day for One Person for One Year, [illegible] Price Level

| Food Items | Pounds | Wholesale Cost | Storage and Handling Cost[a] | Total Cost |
|---|---|---|---|---|
| Canned Meat | [illegible] | $ 41.[illegible] | $0.54 | $ 42.1[illegible] |
| N.F. Dry Milk | [illegible] | [illegible] | 0.71 | [illegible] |
| Dried Eggs | 7 | 0.1[illegible] | 0.0[illegible] | 0.22 |
| Fats and Oils | 2[illegible] | 7.[illegible] | 0.1[illegible] | 7.[illegible] |
| Flour and Other Cereal Products | [illegible] | [illegible] | 1.[illegible] | [illegible] |
| Dried Beans and Peas | 55 | [illegible] | 0.32 | [illegible] |
| Nuts | 11 | 4.21 | 0.15 | 4.[illegible] |
| Dehydrated Potatoes | 1[illegible] | [illegible] | [illegible] | 4.[illegible] |
| Canned Vegetables | 7[illegible] | 1[illegible].41 | [illegible] | 13.[illegible] |
| Canned Fruits | 57 | 15.1[illegible] | [illegible].37 | 1[illegible].5[illegible] |
| Sugar | [illegible] | 3.[illegible] | 0.1[illegible] | [illegible] |
| Instant Coffee and Tea | 6.7 | 14.1[illegible] | [illegible] | 14.2[illegible] |
| Cocoa Powder | [illegible] | 1.[illegible] | [illegible] | 1.[illegible] |
| Total | 757.7 lbs. | $1[illegible]1.4[illegible] | $[illegible] | $1[illegible].[illegible] |

[a]Includes surveillance costs.

## 20.3 ALTERNATIVE ROTATIONAL OUTLETS

### 20.3.1 Normal Chanels of Trade

A nationwide survey conducted by the United States Department of Agriculture in 1963 determined that warehouses held sufficient stocks to provide 10.34 days of food per person at a consumption level of 3000 calories per day.[8] The normal turnover rate of various types of food at the wholesale level is given in Table II.

Table II. Normal Turnover Rate of Various Types of Food at the Wholesale Trade Level[2]

| Food Items | Turnover Rate |
|---|---|
| Canned Fruits and Vegetables | 3 months |
| Flour | 1 month |
| Sugar | 3 days |
| Coffee | 1 month |
| Other Beverages | 2 months |
| Evaporated Milk | 1 month |
| Canned Soups | 3 weeks |

The role of the normal channels of trade as a device for stockpiling food is visualized as a mechanism for increasing the amount of food in the pipeline. In other words, the warehousemen would receive compensation for maintaining above normal inventories of nonperishable food items. The capacity of the normal channels of trade to function as a mechanism for the stockpiling of food is restricted by the amount of nonperishable food that normally flows through the channels. Table III illustrates the quantities of processed or nonperishable food that normally flow through the market

Table III. Annual Per Capita Consumption and Calories and Protein Available From Nonperishable Food Groups, 1[illegible][9,1].

| Food Items | Annual Per Capita Consumption, Pounds | Calories Provided Per Day | Protein Provided per Day, Grams |
|---|---|---|---|
| Canned Meat | 16.00 | 47.3[illegible] | [illegible].1[illegible] |
| N.F. Dry Milk | 5.[illegible] | 20.62 | 2.0[illegible] |
| Dried Eggs | .[illegible][a] | .[illegible] | .0[illegible] |
| Fats and Oils | 20.[illegible]0 | 214.[illegible] | .0[illegible] |
| Flour and Other Cereal Products | 1[illegible]7.[illegible] | 07[illegible].[illegible]1 | 1[illegible].[illegible] |
| Dried Beans Peas and Nuts | 16.9[illegible] | 7[illegible].[illegible] | [illegible].[illegible] |
| Dehydrated Potatoes | .58 | 2.[illegible] | .[illegible] |
| Canned Vegetables | [illegible]9.9[illegible] | 1[illegible].[illegible] | 1.11 |
| Canned Fruits | [illegible].[illegible] | [illegible].[illegible] | .[illegible] |
| Sugar | 1[illegible]1.[illegible] | [illegible].1[illegible] | — |
| Coffee, Tea, and Cocoa | 15.0[illegible] | 11.50 | .18 |
| Totals | [illegible]7.[illegible] | 15[illegible].0[illegible] | [illegible].[illegible] |

[a]Based on production.

channels and is utilized by the consumer, and the food energy and protein available from these supplies.

The "typical" American consumer utilized approximately 403 pounds of processed or nonperishable food in 1967 which furnished sufficient calories for 193 days of food. The protein available from these supplies is primarily of plant origin and sufficient for 159 days. Consumption of these supplies will vary by geographic areas and, over time, gradual changes will occur in the per capita consumption of these food items. If a 6 month turnover rate was assumed for the above supplies, they would provide ample calories for 96.5 days of food. The value of the food items included in this 96 days supply of food would be approximately $40 per person. Thus, for a population of 200 million the value of these inventories would be $7.97 billion dollars. Assuming a 6 month turnover rate, no surveillance costs is charged against the inventories. However, the storage and handling cost would amount to $1.22 per person. Given the assumption that the ownership of the food items remains with the warehousemen and that he receives compensation for maintaining designated levels of inventories, the cost per year of maintaining this program for a population of 200 million would be approximately $722 million dollars, with compensation on the investment of the warehousemen assumed at a rate of 6 percent. Furthermore, it is assumed that the value of the inventories rotated out of storage would be equivalent to their acquisition cost.

All warehousemen would not be capable of bearing the burden of making the additional investment required to accommodate this program. However, another alternative would be for the additional inventories to be owned by the government or provide the capital in the form of a loan to the warehousemen. Furthermore, these calculations are for nonhardened warehouse facilities. Additional incentive would be required for the warehousemen to relocate their facilities outside target areas and for the warehouses to be constructed in such a manner that they possessed a designated protection factor.

The relationship between the nonperishable food which normally flows through the market channels and the previously proposed diet is shown in Table IV. Assuming a yearly turnover rate, the normal channels of trade

Table IV. Relationship Between the Diet Proposed in Table I and the Capacity of the Normal Channels of Trade to Absorb Food Items, 3000 c/day One Person, One Year.

| Food Items | Designated Per Capita Consumption Pounds | Normal Per Capita Consumption Pounds | Stocks To Be Rotated Into Other Outlets Pounds |
|---|---|---|---|
| Canned Meat | 85 | 16.00 | 69.00 |
| N.F. Dry Milk | 93 | 5.90 | 87.10 |
| Dried Eggs | 7 | .04 | 6.96 |
| Fats and Oils | 26 | 20.30 | 5.70 |
| Flour and Other Cereal Products | 298 | 147.[illegible] | 151.[illegible] |
| Dried Beans, Peas and Nuts | 66 | 16.50 | 49.50 |
| Dehydrated Potatoes | 14 | .58 | 13.42 |
| Canned Vegetables | 72 | 45.50 | 26.50 |
| Canned Fruits | 57 | 39.4[illegible] | 17.60 |
| Sugar | 39 | 101.[illegible] | 0 |
| Coffee, Tea, and Cocoa | 9.7 | 15.60 | 0 |
| Totals | 757.7 | 407.82 | 426.73 |

are capable of absorbing 330.92 pounds per capita of the estimated 757.7 pounds of food per capita included in the proposed diet. Consequently, supplies sufficient for 151 days of food can be rotated into the normal channels of trade.

Assuming that the ownership of the reserve stocks rotated into the normal channels of trade remains with the warehousemen, these stocks sufficient for 151 days of food would have an initial value of $66.68 per capita. Thus, the total value of these stocks for a population of 200 million would be approximately $13.3 billion dollars. Maintenance cost of this sector of the program would be approximately $1.23 billion dollars per year. The warehousemen again is compensated at a rate of 6 percent on his investment and storage and handling and surveillance charges are $2.15 per person.

Other rotational outlets would have to be utilized for this program to provide sufficient food for the present U.S. population for one year. Approximately 426 pounds of food must be rotated into other outlets. Alternative outlets include export markets, foreign aid, and rotation into animal feeds. These alternatives are considered in latter sections of this report.

### 20.3.2 Rotation of Food Stocks Into Animal Feeds

The livestock feed industry is a substantial and complex sector of our economy. In 1965 161 million tons of feed concentrates was fed to livestock. Of this total 26.18 million tons were in the form of commercial feeds.[9] Several conventional food products are presently available for use in animal feeds. These products are primarily available due to deterioration in quality or the failure of the product to sell on the market. Some of the products which are available are: dried bakery products, flaked cereals, cake mixes, candy, macaroni, potato chips, and cream substitutes. The feed manufacturers normally do not buy these products directly. They are purchased by intermediate companies which unpackage, screen, grind, and blend them together into a uniform product to offer to the feed manufacturers.[11]

Substantial economic losses are incurred in utilizing conventional

foods in animal feeds. The present technology in the container and packaging industry prevents the utilization of some of the presently available food products in animal feeds. In several instances, due to handling cost, food products in small packaging units are not presently used for animal feed. Therefore, technological progress in the packaging and container industry can exert a tremendous influence upon the economics of converting food products into animal feeds. It may become possible to handle food "without any packaging at all, or at most with a plastic wrapper."[12]

If the assumption was made that the increased unpackaging cost could be overcome, economic losses would still be incurred due to the prices of other feed ingredients. The food products must compete with traditional feed ingredients in the formulation of animal feeds. In the following analysis a value of one and one-half cents per pound was assumed for the food products rotated out of storage into animal feeds. This estimate is based on the present market and the price of other feed ingredients. For example the average price of number 1 fine sun-cured alfalfa meal was 2 cents per pound in 1965, and the average price for number 3 yellow corn in the Kansas City market was 2.27 cents per pound in 1965.[9]

Due to lower quality standards, one major advantage in the rotation of food stocks into animal feeds is the increased acceptable shelf life of conventional foods, thus reducing the handling cost in the storage process. The composition of this diet is identical to the one presented in Table I. Table V shows the shelf life of the food items, replacement stocks required to provide one person 3000 calories per day for one year and the maintenance cost for the operation of this program.

The total cost for the establishment and maintenance of this program for one year for 200 million people would require expenditures in the excess of $37 billion dollars. Approximately $36.3 billion would be required to acquire the stocks, $[illegible] million for storage and handling charges, and an additional $12 million for surveillance expenses. The cost per person is $181.[illegible], $[illegible].42, and $.06 for acquisition of the stocks storage and handling charges, and surveillance cost, respectively.

After establishment, the yearly maintenance cost for the operation of this program would be approximately $34 per person. Expenditures for

Table V. Food Supplies, Shelf Life, and Maintenance Cost of Providing 3000 Calories per Day per Person for One Year.

| | Shelf Life Years | Maintenance Operations | |
|---|---|---|---|
| | | Pounds Per Year | Cost Per Year |
| Canned | 7 | 12.14 | $ 6.38 |
| N.F. Dry Milk | 5 | 18.6 | 5.18 |
| Dried Eggs | 5 | 1.4 | 1.27 |
| Fats and Oils | 5 | 5.2 | 1.66 |
| Flour and Other Cereal Products | 10 | 29.8 | 5.96 |
| Dried Beans and Peas | 10 | 5.5 | 0.92 |
| Nuts | 7 | 1.63 | 0.67 |
| Dehydrated Potatoes | 5 | 2.8 | 0.97 |
| Canned Vegetables | 4 | 18.0 | 3.61 |
| Canned Fruits | 3 | 18.99 | 3.69 |
| Sugar | indefinite | 0 | 0.14 |
| Instant Coffee and Tea | 5 | 1.34 | 2.87 |
| Cocoa Powder | 3 | .99 | 0.55 |
| Totals | | 116.39 | $33.87 |

the replacement of stocks rotated out of storage would amount to $30.06 per person, while storage cost would be approximately $3.79 per person. Thus, for a population of 200 million a yearly outlay of approximately $6.77 billion dollars would be required to maintain the stocks. Additional expenditures would also be incurred due to the expected premature spoilage of some food items. Approximately 116 pounds of food per capita would be annually rotated out of storage into animal feeds. The value of these stocks rotated into animal feeds is approximately $349 million dollars which is less than one-fourth of the first years interest on the original investment, assuming an interest rate of 6 percent. This illustrates the prohibitive nature of the economic losses sustained in rotating conventional foods into animal feeds.

### [illegible] Other Outlets

It might appear that the federal food distribution programs would be capable of functioning as a rotational outlet for reserve stocks. However, the magnitude of these programs is insignificiant in terms of their capacity to absorb stocks rotated out of storage. For example, in the year beginning July 1, 1965 on the basis of a population of 194 million people the school lunch program utilized only 3.[illegible]4 pounds of food per capita. Likewise, the food distribution programs serving institutions and needy persons would have provided only 5 pounds of food per capita.

Other outlets that could be considered include rotation of the food items into export markets and the coordination of this program with the foreign aid program. However, these reserve stocks would be distributed throughout the United States resulting in a complex and expensive tranportation problem. Other types of food would appear to be more suitable for the foreign aid program. Furthermore, in the donation of food caution must be exercised so that the food aid does not reduce the incentives of indigenous food producers.[13]

## 20.4 REFERENCES


1. National Commission of Farm Marketing, Cost Components of Farm--Retail Price Spreads for Foods, Technical Study Number 9, June 1966: and Marketing and Transportation Situation, USDA, MTS 160 (February, 1966).

2. M. E. Juilly et al., "Food Storage, Packaging and Surveillance," Food Technology, XVI (August, 1962), pp 25-27.

3. Family Food Stockpile For Survival, USDA, Bulletin Number 77, August 1963.

4. S. R. Cecil and J. G. Woodroof, "The Stability of Canned Foods in Long-Term Storage," Food Technology, XVII (May, 1963), pp 131-137.

5. E. C. Taylor et al., "Food Selection and Ration Concepts," Food Technology, XVI (September, 1962), pp 39-44.

6. Inventory Management Division Commodity Management Branch, ASCS, USDA, Average Storage Rates and Weighted Average Storage Rates, October 11, 1965, Mimeo.

7. Recommended Dietary Allowances, National Academy of Sciences National Research Council Publication 1146 (Washington, 1964), p 7.

8. Food Supplies Available by Counties in Case of a National Emergency, USDA, Agricultural Economics Report Number 57.

9. Agricultural Statistics 1967, USDA (Washington, 1967).

10. U. S. Food Consumption, USDA Statistical Bulletin Number 364 (October, 1965).

11. John A. Costa, "High Energy Products Available for Feed Manufacturers," Feedstuffs, XXXIX (October 14, 1967), p 48.

12. Hans H. Landsberg, Natural Resources for U.S. Growth (Baltimore, 1965), p 77.

13. Food and Fiber for the Future, Report of the National Advisory Commission on Food and Fiber, (Washington, July 1967), p 132.

# 21. PLANNING FOR ECONOMIC RECOVERY FROM THERMONUCLEAR ATTACK

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## 21.1 INTRODUCTION

### 21.1.1 Basic Assumptions

Planning for postattack economic recovery must rely on assumptions as to (1) the extent of attack damage and (2) its effect on the customary social and economic institutions. We have not accepted the hypothesis that the nuclear disaster merely represents one segment of a "disaster continuum." This continuum concept, explicit in some of the surveys of past disasters and implicit in other such studies, appears to us to suggest that the differences between light, medium and heavy nuclear attacks can be conceived of in terms of differences in the time dimension of the recovery period and/or in the spatial extent of the consequences. Instead we believe that different levels of attack may involve qualitative as well as quantitative variations and that different kinds of recovery plans may be called for in each case.

From the point of view of economic impacts it is useful to establish at least three attack classes or levels. One, a "light to moderate" attack, can be defined as an attack which does not threaten the viability of the economic system as we know it preattack. It is difficult to indicate specifically the magnitude of this type of attack, but perhaps it would fall in the 0-2,000 megaton range. This is the type of attack from which we can recover by "muddling through" with essentially our present policies and approaches. Good or bad planning may hasten or retard the process, but recovery can be brought about without any fundamental change in our economic institutions.

A second level of attack we will call "heavy". Such an attack might range in megatonnage between 4,000 and 20,000; it is an attack of sufficient size to place recovery in doubt under present plans and policies. By definition there will be little or no margin for the sort of gross planning errors that merely retarded the economic recovery of the Soviet

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Union after 1917, or of the United States after 1929. Rather the quality of preattack preparation and of postattack implementation and adjustment will play a crucial role in determining whether or not recovery will take place.* To paraphrase some of Winter's work,[1] in the "heavy" attack case recovery will depend on the outcome of a race between the reestablishment of output to subsistence levels and the depletion of our preattack stocks of subsistence goods. Whether the race is won by growing output, resulting in recovery, or by the depletion of stocks and the ultimate disappearance of a viable nation, is critically dependent on the quality of preattack economic planning.**

A third level of attack might, for lack of a better phrase, be called "ultimate." This is an attack of such a magnitude, perhaps involving delivery of 50,000 megatons, that national recovery is beyond hope. While such an attack differs in megatonnage from the "light to moderate" or "heavy" attacks by a scale factor, the economic effects of these variations are clearly discontinuous. While the "ultimate" case appears to be ruled out now and in the near future by technological consideration, we include it in the discussion to complete the set of theoretical possibilities.***

Neither the first nor the third level of attack has been extensively considered by us in our approach to the recovery problem. For the "light to moderate" attack it is our impression that present plans and preparations may be sufficient; for the "ultimate" attack preparations at any level may save lives, but the restoration of a viable economic system within

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*Recovery is rather narrowly defined here to mean the attainment of sustained economic growth, i.e. production in excess of current consumption, within at least one generation, without an extensive loss of life due to shortages in the interim.

**It is also dependent on the survival of a strong central government and on a set of public attitudes compatible with recovery organization. These are non-economic factors, but we have considered them where relevant to economic planning.

***An example of such an attack might be many tens of thousands of megatons of groundburst weapons which might deny access to land for so long that evacuation of the survivors would be necessary.

the borders of the country in any reasonable time period appears to be essentially impossible regardless of the state of preparedness. Our emphasis has been on the case of the "heavy" attack. This is of paramount analytical interest since it is the case where the nature and extent of preattack planning and preparation can be of extreme significance in determining the ultimate outcome.

So far we have classified nuclear attack only in terms of magnitude. Also of importance from the standpoint of postattack recovery is the question of the distribution of the attack. From an economic standpoint, distribution of the attack is a question of the effect on the surviving ratio of capital to labor. The relationship of the postattack ratio to the preattack ratio may depend on a number of factors: targeting (anti-countermeasure, anti-population, anti-recovery), warning time, degree of hardening and/or dispersal extent of shelter development, and similar factors. Three possible cases are illustrated in the column headings of Figure 1. When these are combined with the threefold classification of attack magnitude, nine cases of at least theoretical interest appear.*

As indicated on the column headings of Figure 1, as a result of nuclear attack, per capita wealth positions (here wealth is proportional to the gross capital stock) may increase, decrease, or remain unchanged. Since we have already argued that attention should be confined to the "heavy" scale and spatial effects, these are the cases in which survival of the system and ultimate recovery might be a significant problem and

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*For the sake of simplicity, other possible dimensions of the problem have not been specified in this summary statement. If the overall C/L ratio remains constant, for example, while the ratios differ in various geographical areas the number of cases increase. Similarly, it makes a difference whether or not the production function is or is not linear and homogeneous even when the C/L ratio remains unchanged since the "efficiency" of production processes may vary directly, propotionately, or inversely with the size or "scale" of the capital input. Thus proportional survival of output potential. A severe reduction in the absolute size of the nation's capital stock may impose output burdens due merely to lost scale economies.

This discussion also assumes that the preattack C/L ratio was satisfactory, if not ideal. The fact that our economic growth has generally been regarded as satisfactory over recent decades suggests that this assumption may not be unwarranted.

| | Non-proportional/Survival Favorable $\left[\frac{C_1}{L_1}\right] > \left[\frac{C_o}{L_o}\right]$ | Proportional/Survival Neutral $\left[\frac{C_1}{L_1}\right] = \left[\frac{C_o}{L_o}\right]$ | Non-proportional/Survival Unfavorable $\left[\frac{C_1}{L_1}\right] < \left[\frac{C_o}{L_o}\right]$ |
|---|---|---|---|
| Light to Moderate | CASE I<br>Minimal problem of economic recovery; prior planning relatively unimportant | CASE II<br>Economic recovery assured; little prior planning requires | CASE III<br>Delayed recovery; planning helpful |
| Heavy | CASE IV<br>Delayed recovery; planning important | CASE V<br>Delayed recovery; planning very important | CASE VI<br>Recovery in doubt; planning of perhaps crucial importance |
| Ultimate | CASE VII<br>Ultimate economic collapse | CASE VIII<br>Ultimate economic collapse | CASE IX<br>Ultimate economic collapse |

Symbols: C = capital stock; L = labor force; subscripts refer to time periods, o = preattack, 1 = postattack

Figure 21.1. Classification of Economic Impacts of Various Types of Nuclear Attack

where a major planning effort might be justified.

If fact, the focus of our study is narrower. Case VI, where recovery is only possible is of greatest interest, and we have confined our attention to the situation in which a "heavy" attack results in a decline in surviving capital wealth per capita. A solution of case VI can be said to solve all problems which at present appear to be both significant and solvable. Furthermore, the underlying assumptions of the non-favorable recovery case is consistent with the focus of other activities in the ORNL Civil Defense Research Project aimed at the preservation of lives in the event of a heavy attack. A system designed to save lives must also be concerned with the reestablishment of an economic system capable of supporting the survivors.

In summary, then, the basic point of view of our study is that recovery is "at risk" under present policies and with present preparations. This means all aspects of the economic system must be examined for their possible reaction to attack and for the alternatives we may reasonably expect to be available to assure that our economic institutions will meet the requirements of the postattack environment.

### 21.1.2 Problems of Underdeveloped Areas as a Model

It is usually helpful in thinking about the unknown to relate it as far as possible to what is known. Thus the literature dealing with nuclear disaster contains a number of references to past disasters as a frame of reference. Similarly the idea of a "disaster continuum" represents such an attempt. We believe it more fruitful, however, to find a parallel between the problem of post attack recovery and the problems faced by underdeveloped countries.

Economies facing development or redevelopment are confronted by many of the same problems. In both situations, for example, primary activity (agriculture and other extractive industries) is likely to predominate, with the policy emphasis concentrated on establishing or reestablishing secondary activity (manufacturing). A second parallel involves the capital/labor ratio. In the "survival unfavorable" case

on which our attention is focused this ratio is likely to be quite low, as it is today in the underdeveloped areas of the world.

A third similarity involves lack of spatial integration. In both cases spatial "dualism" is likely to be characteristic. Dependence on the outside world may be another area of similarity. Just as underdeveloped areas are heavily dependent upon the developed world for development imports, so may the redeveloping world be dependent upon the surviving portion of the world economy.

A major characteristic of the underdeveloped world is lack of the appropriate infrastructure--the melange of basic industries and facilities such as transport and communications on which the entire industrial superstructure depends. It is our feeling that establishing the appropriate infrastructure particularly in its institutional dimensions, may be the most formidable task in planning for post attack recovery. Furthermore, infrastructure industries such as railroads, communications and banking are likely to suffer more physical damage than other industries which are more widely dispered or less vulnerable.

Techniques of production which are suitable in one economic climate are often unworkable in others. It pays many American farmers to use a great deal of machinery, but the use of a tractor or a similar labor saving device would be completely out of the question in mud of India. Thus although "advanced technology" is available to the underdeveloped economies it is often not adaptable to their situation. The appropriate technology at any one time and in any place depends on the price ratios for productive inputs (such as land, labor, capital and management skill) which in turn reflect the relative scarcities of these resources. Distortions in the C/L ratio as a result of nuclear attack would render many of our production techniques just as useless at home as they are at present in the backward areas of the world. Adjustment to a new pattern of relative resource scarcity may be difficult since it may require operating on a portion of the production surface with which we have had little or no experience.

Extremes of wealth and proverty are characteristic of most underdeveloped areas. Similar inequalities would no doubt exist in a

postattack society due to unique initial positions and the uneven distribution of prompt and residual attack effects. Some argue that in both the development and reconstruction cases some measure of income and wealth equalization is prerequisite to further expansionary activities. Further discussion of this problem is found in Part 3 of this chapter.

On the basis of these observations, we think the analyst can profit from thinking about the recovery problem in the context of the development problem. At the same time we should be aware of the risk of pushing an analogy too far. While there appear to be obvious parallels there are also important differences. For example, the postattack economy will survive with some capital resources which are much more sophisticated than those available in underdeveloped countries. Furthermore the surviving population will be one experienced in responding to the stimulus of economic reward, a population accustomed to change and to adaptation to change, a relatively well educated population, and a population with a high skill level. Additional differences could be indicated, but the important fact is that thinking in terms of underdevelopment, while by no means the whole of the analysis of postattack economic recuperation, does at least provide a desirable tie with a present reality and does at least indicate a starting point in the specification of some of the problems. Such an approach, for example, brings out the probable need for some important institutional changes if recovery activity is to be quickly and effectively undertaken.

## 21.2 THE BASIC PROBLEM

The basic problem is how to provide preattack for the survival and recovery of the nation's economy. The solution path involves detailed studies of the industries somehow determined as essential in order to establish their critical survival and recovery characteristics. Such investigations would examine factors such as location, adaptability of various production processes to input substitution, and the nature of possible dependency relationships among and within these essential industries.

However, a modern economic system involves more than physical production. To function at all it requires complex supporting and facilitating institutions. These include systems for physical distribution, communications, and finance, and, most important of all, an over-all control mechanism. In the United States the latter is frequently described as "free market", although as Galbraith[2] has noted our most important economic activities are decreasingly left to the vargaries of the market place as corporate planners and political administrations work to eliminate economic uncertainty. At any rate it appears folly to ignore the infrastructure by assuming it will function essentially unchanged following an attack. Equally unsatisfactory, it seems to us, is the attitude that certain preattack institutions are so sacred that their failure to operate unchanged is equated with a failure of the entire political economic system. Opposition to contingency planning for monetary reform may fit this category.

The probable nuclear damage to our nation's economic infrastructure is increased by the geographic concentration of its physical aspects. Furthermore, the impact of nuclear attack on the infrastructure sectors may differ substantially from that of the goods producing sectors where the important dimension of damage is physical or quantitative. The infrastructure may also suffer intangible or qualitative damage, probably because of the physical losses, but also because of possible changes in economic expectations resulting in a conflict between the short-run goals of the individual and the long-run recovery goals of the society.

## 21.3 ECONOMIC ORGANIZATION AND CONTROL

The organization of an economic system might well be considered the most important of economic resources--where economic organization is defined as the framework of laws and customs that direct and constrain individual and corporate behavior. In a "well organized" economic system individual behavior will generally be in harmony with the overall goals of society. Thus in our society the individual is directed, primarily by economic incentive, to produce the goods and services society wants. The

values of the society partly determine the wants and therefore the kinds of legitimate economic activity.

Thus at a moment of time, a satisfactorily functioning or equilibrium economic system is a melange of individual and collective activities, directed primarily by economic incentive, and constrained by the values of the society. The equilibrium economic organization for the postattack economy will be different to the degree that values are different and perhaps also to the degree that there is perceived "slack" or "margin for error" in the system. Hence any attempt to plan the ideal postattack economic system must make some assumptions with respect to values and to slack. The usual assumption in the literature is that postattack values will be the same as preattack. However it appears to us that the weights assigned to particular values change according to the perceived slack. For example economic, and to some extent political freedoms, received much less emphasis during all-out war than in the normal peacetime environment. Given our assumption of "recovery at risk" we believe that extensive controls designed to assure the optimal allocation of survival and recovery resources will be acceptable as well as necessary.

We would not go so far as to characterize this state of affairs as "disaster socialism," a term used in the Project Harbor report[3] to describe a complete postattack government takeover. While there may be substantial intervention by the Federal Government, we would expect all such measures to be regarded as temporary. Once recovery has been accomplished we have no reason to presume that the basic values of the preattack society will not resume their normal weights.

What are the areas that may require a degree of government intervention? In addition to the customary intrusion into the allocation of essential productive resources and scarce consumer goods, a nuclear war would bring new problems. One of these is the indemnity question. There will also be a set of special problems facing the business sector. These are management succession, asset ownership, and debt moritoria. Although we have found some recognition of these problems in the literature there are relatively few solutions suggested that fit our view of the postattack environment.

### 21.3.1 Problems of Ownership, Succession and Debt Monitoria

An attack of the magnitude assumed here would probably wreck heavy damage on many corporate headquarters and financial record centers. Would the managers of branch plants located in the hinterlands be able to make decisions if the home office has been wiped out? Who would have the authority to make the necessary staff realignments and policy decisions? One expedient would be the appointment of the senior man in each plant so affected as a Federal agent for the duration of the emergency, authorizing him to manage the plant in the same way that he might if he had received complete authority from corporate headquarters, subject to any additional constraints imposed by the recovery plan.

Several authors have discussed the special problem of debtor-creditor relations[4,5,6]. It is their consensus, and ours, that some sort of debt moratorium would be necessary. However, present official plans restrict moratoria to "hardship cases" perhaps to avoid what one official study described as "paralysis and decay" and loss of "all economic momentum"[7]. For the sort of misfortune assumed here, paralysis, decay, and the failure to regain economic momentum are more likely to result from an imposition of the dead hand of debt than from the recognition by both debtor and creditor that the fortunes of war had left them both facing a _tabula rasa_.

There is also the problem of ownership and control of assets unclaimed by preattack owners or their immediate heirs. Normal legal procedures will be impossible in the immediate postattack period because of the probable vast number of cases and the urgency of resuming production. A reasonable suggestion requires the government to assume ownership until the recovery has been accomplished and such property can be sold to the public or returned to its legally determined owners.

### 21.3.2 Postattack Economic Controls

The recovery problem is to organize the surviving resources so that economic growth--recovery--can begin. The resource inputs include labor,

the goods and services necessary to maintain labor (wage goods), the capital goods and materials necessary to produce wage goods, and capital goods for replacement and growth. During the early postattack period output may be less than current consumption with the difference coming from preattack stocks of wage and capital goods. But if recovery is to take place at all, output must grow to equal and finally to surpass mere survival levels of consumption.

Recovery will be assured and speeded to the degree that inputs and stocks are allocated to their most efficient recovery use. By our assumption there will be no slack in the economy--no possibility of safely permitting non-essential consumption. However, non-essential consumption, and the production to support it, will take place, except under fairly rigorous controls. This is because postattack wealth and income positions will not be homogenous. Some individuals will be left with wealth or provided with income sufficient to take care of their essential needs and to permit them to demand non-essentials as well. In terms of minimizing the time required to reach the recovery take-off stage, this "excess" demand, if satisfied out of current production or out of stocks of otherwise essential goods, can be described as wasteful.

One solution of this problem simply calls for the confiscation of all such "excess" income and wealth. This is not generally assumed to be feasible because (a) it contradicts flagrantly our traditional ideology concerning wealth and income, (b) it would probably have severe disincentive effects, contributing to more waste than it would alleviate, and (c) it would be very difficult to administer.

Thus we are left with the problem of allocating the postattack resources to minimize recovery time (or to maximize survival and recovery output), subject to the constraints that everyone is provided with essentials for living and working and that the disincentive effects of the control system do not offset its theoretical gains.

Present official plans for postattack resource allocation are largely of a conventional "tried and true" sort. As outlined in the National Plan and other publications[8] these approaches rely on some mixture of monetary and fiscal controls to prop up and regulate the

financial sectors while rationing and price controls are used to allocate consumer goods and services. A significant innovation over the World War II system is the allocation of material resources through a computerized system (PARM) developed by the National Planning Association.

Assuming adequate information on stocks and flows, this system should provide much better materials allocation than was heretofore possible simply because the internal consistency of the allocative system may be determined _ex ante_ rather than _ex post_. A considerable body of criticism of this approach already exists.[7] Generally these criticisms imply that the envisioned controls won't work because they haven't worked in the past, or that they won't work because the damage will be too severe for all but the most rigorous of controls. The first criticism we believe to be wrong at worst and unfair at best. Considering the magnitude of the problem in a pre-computer, pre-input/output matrix age, the control system of World War II worked very well in the United States. At least production rose to meet record needs and prices were held reasonably in line. If German or Italian postwar experience with these sorts of controls is taken as an indicator, the performance appears much worse. However, in neither of these countries is the experience symmetric with what we might expect postattack. Thus we would expect that for the attack effects hypothesized in cases I-IV and perhaps even in Case V of Figure 1 the existing plans would be satisfactory, although perhaps not ideal for each case. Should results fail to bear this out, official plans can be adjusted. For in none of these cases is recovery itself in doubt -- only the duration of the recovery period will be affected by the quality of the economic control mechanism.

But as implied above we do not believe that the present official plans are adequate for the case VI situation, with recovery in doubt. And, by our definition of this postattack environment there will not be enough time (resources) to allow for the luxury of adjusting the policies as the need arises. Thus while it is conceivable that plans for currency reform can safely be postponed until the actual need for such a drastic step has become obvious, it should also be realized that in a given situation there may not be enough time to devise a proper plan. [illegible]ving one

on the shelf makes more sense.

This is not to deny a rational basis for refusing to develop alternative plans to fit different postattack situations. There is a fear, not without historical precedent, that the imposition of an unfamiliar control system would trigger a "crisis of confidence" which in turn would lead to the abandonment of money as a medium of exchange and immediate revision to a barter economy.[9] Thus a "business as usual" approach, relying only on more familiar qualitiative controls, is supposed to maintain economic momentum in the crucial days immediately following a nuclear attack.

There are additional problems connected with any alternatives that involve currency reform. It requires central bank control which in turn implies some degree of central government survival. And, if there are preattack expectations of postattack currency reform, a period of rising international tensions could precipitate a monetary crisis as people attempted to convert their more liquid assets into "hard goods" that might be expected to maintain or increase in value postattack.

Each of these objections may have validity given certain circumstances. But for the postattack situation we have assumed they may not be overriding even if they are otherwise valid. Before describing one possible variant of an alternative economic control mechanism we will outline briefly our view of the above objections to non-traditional control methods.

First of all, with respect to the crisis of confidence, we believe that the overall crisis is going to be such that particular economic measures which are in themselves workable cannot magnify the crisis. The early days of the postattack period will hardly be a time to expect any investment activity. Rather drastic economic policies that are forthrightly advanced by the central government (or its surrogate, the Federal Reserve System) may be welcomed and inspire the sort of confidence that will lead to an early contribution to recovery from the private sector. On the other hand an unsuccessful attempt to maintain familiar institutions may retard recovery and may also have undesirable effects on expectations that carry over into any reform period.

A possibility of barter makes some sense in a nation of small shopkeepers with an unspecialized agriculture. The highly specialized interdependence of the U.S. economy seems to render this impossible today. It is difficult to imagine the postattack housewife negotiating a barter transaction with the manager of her local A&P, or treking to the countryside to trade for milk and eggs. Thus resort to barter no longer appears to be a reasonably possible alternative for an otherwise unacceptable monetary system.

The possible absence of centralized government influence during the early days of recovery could be an important objection to the immediate or early imposition of a non-traditional control system. However we are fortunate in having a central banking system that could survive all but the ultimate attacks. This is because of the geographic dispersion of the twelve district banks and their branches. A further contribution to the central banks survival potential could easily come from more preattack preparation to provide for any one of the district banks to assume full central bank authority to immediately implement the required policies This could be accomplished in spite of a need to rely on state and local government's response to meet other requirements in the absence of a well organized federal government.

The last major objection is the most serious. It is quite possible that preattack expectation of severe monetary controls would lead to a preattack monetary crisis, if not a collapse, as people attempted to convert their money and securities into assets that they expected to have greater value postattack. The seriousness of this possibility depends on the perception of the international crisis as one likely to lead to a nuclear attack, on the duration of the international crisis, and on the speed with which the monetary authority can counteract this speculative activity with monetary controls.

In spite of the seriousness of this objection we do not accept it as overriding for two reasons. First this very reaction is possible anyway, without any prepublished plans for an "objectionable" postattack monetary control; i.e. the very nature of a preattack crisis would lead to a revision of normal investment and saving criteria. Second, unless

the monetary authority is somehow paralyzed, as a preattack money and credit crisis develops it can be halted and/or its effects mitigated.

### 21.3.3 Alternatives to the Present Plan

A control system suitable for use in emergencies differs from those desired in "normal" periods primarily because of the differences in tolerance. We can tolerate controls only because we cannot accept the effects of their absence. In either case the goal is an efficient and equitable allocation of resources; the difference derives from the abnormal scarity of resources.

The traditional techniques for wartime or postwar resource allocation have often been frustrated because the flows of spendable incomes and of consumer goods could not be equalized. Taxes and wage controls were relied upon to regulate the bulk of consumer income. Price controls and rationing schemes were to determine the allocation of final output to consumers. However, since incentives are normally necessary to insure maximum individual work effort, earnings will normally differ. This means that some households, making allowance for differing needs according to size and composition, will have disposable incomes in excess of other households and that the sum of disposable incomes may exceed the controlled market value of the available goods and services. Thus unless the vast bulk of buyers and sellers are willing to repress the desire for increased consumption and profit, violations of rationing and price control laws will significantly determine how wage goods are distributed. If the available supply of these goods is close to minimal an "excess" level of consumption for some means deficiency for others and presumably a retardation of the recovery effort. Furthermore, while inflation is usually undesirable per se, (it is sometimes referred to as a "cruel tax on those with relatively fixed incomes"), a severe inflation might also retard recovery by redirecting private efforts into attempts to take advantage of or to avoid the effects of rapidly rising prices. Thus a system that places more effective control over the disposition of incomes is needed.

Before the advent of computerized bank record-keeping it was probably

fair to claim that many of the alternatives to price control-rationing systems were too cumbersome to be efficient. This hardly seems reasonable today when currency represents only about 22 per cent of the total money supply.* The elimination of paper currency as a medium of exchange would contribute to solving the control problem since check transactions are relatively easy to trace. With all receipts and expenditures being handled through the banking system, it then becomes technically possible to control consumer and perhaps business expenditures by allocating income between disposable and blocked accounts. This would permit equitable distribution of the available goods and services with current consumption limited to the funds available in the disposable account.

Blocked account funds would be available to meet abnormal consumption needs but would generally represent a form of forced savings. Since the main function of the blocked account is to permit incentive incomes while preventing important differences in per capita command over consumer goods, an interest paid on these blocked accounts might be desirable. A blocked account would thus be analogous to a savings account, albeit "forced." As the recovery effort progressed, blocked account funds could be released to permit higher consumption levels.

Rationing and price control may or may not be required when currently disposable incomes are regulated. Without intensive investigation it appears possible that these controls would be generally unnecessary, thus allowing for individual differences in consumption and permitting the price system to work in its most efficient role of providing signals of shortage or surplus. Furthermore, flexible prices would ease the task of the planners who must allocate resources for investment and production, a much more difficult job if they have to wait for complaints and the growth of illegal markets to indicate a need for changes in planning. The absence of general rationing would also reduce the bureaucratic work load and the problem of planning.

*The money supply used here is currency held outside banks plus demand deposits. Some economists have argued that time deposits at commercial banks should be included. If this is done, the currency fraction drops to 11.7 per cent for 1966.

As noted above, incentive wage and salary payments are an important cause of difficulty in a conventional control system. Would a system of equalizing disposable income at minimum levels have disincentive effects? We believe that so long as there was general confidence as to the eventual recovery of the economy there would be a willingness to accumulate "savings" to support a higher level of consumption after recovery. The experience of the United States during World War II provides precedent for this hypothesis.*

Viewed from a preattack perspective, plans that call for the elimination of paper currency may seem too harsh and unlikely to receive a great deal of preattack approbation. Yet the system outlined above, or some variation of it, would appear to yield the least interference with the normal market process and to permit the smoothest end to controls whenever that becomes possible.

Certainly these control plans need further study. In particular these and any other proposed control systems need to be fitted to current and known potential technological developments in banking. Conceivably the entire problem of regulating aggregate demand and directing output could be approached by adapting a system analogous to the methods now under study by some major banks, where retail purchases would be immediately deducted from the customer's account by his bank.

Any system devised should meet the following criteria as proposed by Enke[7]: (1) allow flexible production and consumption as needs and capabilities change; (2) encourage the reallocation of resources to their most important recovery use minimizing current consumption; (3) guarantee that minimum consumption needs of all are met; (4) keep the administrative cost as low as is consistent with the other criteria. An additional necessity for a smoothly functioning control system is that it be largely "self-enforcing." This means that individuals must generally find it

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*See Galbraith[10] for an argument that high elasticity of expectations on the part of the average worker prevented a disincentive effect as savings accumulated to record levels during World War II.

most profitable to function within the system, i.e., immediate self-interest should encourage behavior consistent with the overall recovery goals.*

The strengths and weaknesses of the present "official" plans for resource allocation during the survival and recovery period are reasonably well known since they are revised versions of the World War II systems. Except for some early work by Scitovsky, et. al.[13] and a brief article by Enke in 1958[14] there seems to have been little detailed study of alternatives by an official body such as the Treasury, the Federal Reserve or the Office of Emergency Planning. Considering the theoretical potential that some variant of a dual account system would have, we believe it is worthy of detailed study and consideration.

*George Katona,[11] in a field study of price control and business behavior, found that violations increased to the degree that the regulations "didn't make sense" or seemed to threaten the firm's survival. The mere opportunity for black market profits appeared less likely to attract violation. See also Victor A. Thompson.[12]

## 21.4 REFERENCES


1. Sidney G. Winter, Jr., Economic Viability After Thermon-lear War: The Limits of Feasible Production, Santa Monica, The Rand Corporation September 1963. p 17-26 RM-3436-PR.

2. J. K. Galbraith, The New Industrial State, Boston, Houghton Mifflin Company, 1967.

3. J. Hirshliefer, et al., "Postattack Recovery Program, Social and Economic Aspects," in Report of Project Harbor, Panel D, Part II, National Academy of Sciences, National Research Council, 1963.

4. H. Kahn, On Thermonuclear War, Second Edition, Princeton, Princeton University Press, 1961.

5. D. F. Cavers, "Legal Measures to Mitigate the Economic Impact of Atomic Attack," Bulletin of Atomic Science, vol. 9, 1953, pp 269-272.

6. J. Hirshliefer, Economic Recovery, Santa Monica, The Rand Corporation, August, 1965, AD 626 605.

7. Paul Berry, (ed.), Source Book on Non-Military Defense, vol. VI, Hudson Institute, September, 1964. (Specific works within this volume are referred to by number.) #47, p 404, #46, #49, p 434.

8. Office of Emergency Planning, Money Credit and Banking in a Post-attack Emergency, June 1965.

9. These statements are reasonably accurate paraphrases of comments by responsible officials in letters to D. Patterson.

10. J. K. Galbraith, A Theory of Price Control, Cambridge, Harvard University Press, 1952. pp36-37

11. George Katona, Price Control and Business, Bloomington, Indiana, The Principia Press, 1945.

12. Victor A. Thompson, The Regulatory Process in OPA Rationing, New York, Kings Grove Press, 1950.

13. Tibor Scitovsky, Edward Shaw and Lorie Tarshis, Mobilizing Resources for War, New York, McGraw-Hill, 1951.

14. Stephen Enke, Controlling Consumers During Future Wars and Their Aftermath, Reve. Ed., Santa Monica, The Rand Corporation, 1958.

# VIII. PUBLICATIONS AND TALKS

## ORNL REPORTS

L. Dresner and C. V. Chester, A Four-Inch Shock Tube Driven by an Explosive Gas Mixture, ORNL-TM-2094, March 1968.

Joanne S. Levey, Ann S. Klein and Joanne Nelson, Indexes to 780 Unclassified Documents on Civil Defense, ORNL-CD-2, January 1968.

Joanne S. Levey, Ann S. Klein, Joanne Nelson, and Bobbie Jean Hatcher, Indexes to 743 Civil Defense Documents (Classified and Unclassified, Limited Distribution) ORNL-CD-3, April 1968.

Joanne S. Levey, Ann S. Klein, and Bobbie Jean Hatcher, Indexes to 563 Unclassified Documents on Civil Defense, ORNL-CD-4, April 1968.

R. A. Uher, A Defense System Design Model, ORNL-TM-2041, February 1968.

R. A. Uher, The Role of a Blast Shelter System in Strategic Defense, ORNL-TM-2134, March 1968.

Annual Progress Report, Civil Defense Research Project, March 1966-March 1967, ORNL-4184, Part I, Unclassified.

Annual Progress Report, Civil Defense Research Project, March 1966-March 1967, ORNL-4184, Part II, Secret Defense Information.

Annual Progress Report, Civil Defense Research Project, March 1966-March 1967, ORNL-4184, Part III, Secret Restricted Data, Sigma I.

Tom Atkinson, A Propositional Inventory of the Empirical Work Involving Foreign Affairs and National Security Attitudes, 1960-1966: A Non-Evaluative Review, ORNL-TM-2029, October, 1967.

Davis B. Bobrow and Allen R. Wilcox, Structure of American National Security Attitudes, ORNL-TM-1818, October 1967.

Sue B. Bobrow, Responses of Influentials to Negative Contingencies, ORNL-TM-1817, November 1967.

L. Dresner, The Variation of Shock Overpressure with Distance in an Explosively Driven Shock Tube, ORNL-TM-1966, September 1967.

L. Dresner, Viscous Attenuation of Explosive Shocks in Tubes, ORNL-TM-1823, June 1967.

Erik V. Nordheim and Pamela B. Wilcox, Major Events of the Nuclear Age: A Chronology to Assist in the Analysis of American Public Opinion, ORNL-TM-1830, August 1967.

Allen R. Wilcox, Indices of Qualitative Variation, ORNL-TM-1919, October 1967.

## OPEN LITERATURE

A. F. Shinn, "Food Crops and Postattack Recovery," The Proceedings of the Symposium on Postattack Recovery from Nuclear War, Ft. Monroe, Virginia, April 1968 (Proceedings of the Postattack Recovery Symposium of the National Academy of Sciences--National Research Council, Ft. Monroe, Virginia, November 6-9, 1967).

A. F. Shinn, S. I. Auerbach and D. A. Crossley, Jr., "Postattack Insect Problems," The Proceedings of the Symposium on Postattack Recovery from Nuclear War, Ft. Monroe, Virginia, April 1968 (Proceedings of the Postattack Recovery Symposium of the National Academy of Sciences--National Research Council, Ft. Monroe, Virginia, November 6-9, 1967).

M. C. Bell, Airborne Radionuclides and Animals, "Agriculture and the Quality of Our Environment," AAS Symposium No. 85, 1967, N. C. Brady ed., 476 .

Davis B. Bobrow, "National Security Research," Political Science Panel, BASS Survey of Behavioral and Social Sciences, 1967, pp. 8-13.

Davis B. Bobrow and Neal E. Cutler, Time-Oriented Explanations of National Security Beliefs: Cohort, Life-Stage and Situation, Peace Research Society Papers, VIII, 1967, pp. 31-57 (Paper presented at the Annual Meeting of the Peace Research Society (International), The Hague, August 29-31, 1967).

## PRESENTATIONS

Davis B. Bobrow, "National Security Attitude Research," Committee on International Relations Society for the Psychological Study of Social Issues of the American Psychological Association, Evanston, Illinois, March 16, 1968.

Davis B. Bobrow, "Consequences of the Use of Military Power," Annual Meeting of the International Studies Association, Washington, March 30, 1968.

Davis B. Bobrow, "International Decision-Making: The Need for National Profiles," Quantitative International Politics Theory Symposium, Center for Advanced Study in the Behavioral Sciences, Stanford, California, March 26, 1968, <u>International Studies Quarterly</u> (forthcoming).

Davis B. Bobrow, "Analytic Applications - Examples on the Beliefs of Populations" Computers and Foreign Affairs, Foreign Service Institute, Arlington, Virginia, March 1, 1968.

Davis B. Bobrow, "ORNL Social Science Research," Peace Research Group, University of Lund, Lund, Sweden, September 20, 1967.

Davis B. Bobrow, "Social Science Information Retrieval: The ORNL Approach," Annual Meeting of the Council of Social Science Data Archives, Los Angeles, June 15, 1967.

J. C. Bresee, <u>Project Harbor in Retrospect</u>, September, 1967, presented at Systems Development Corporation, Santa Monica, California.